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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ANIMAL INDUSTRY.—CIRCULAR 153.

A. D. MELVIN, CHIEF OF BUREAU.

THE DISSEMINATION OF DISEASE BY DAIRY PRODUCTS, AND METHODS FOR PREVENTION.

I. MILK AS A CARRIER OF CONTAGIOUS DISEASE, AND THE DESIRABILITY OF PASTEURIZATION.

By G. LLOYD MAGRUDER.

II. THE IMPORTANCE OF A WHOLESOME MILK SUPPLY.

By JOHN R. MOHLER.

III. THE RELATION OF THE TUBERCULOUS COW TO PUBLIC HEALTH.

By E. C. SCHROEDER.

IV. INTERPRETATION OF RESULTS OF BACTERIOLOGICAL EXAMINATION OF MILK.

By L. A. ROGERS AND S. H. AYERS.

V. PASTEURIZATION, ITS ADVANTAGES AND DISADVANTAGES.

By M. J. ROSENAU.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1910.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Washington, D. C., January 24, 1910.

SIR: I have the honor to transmit herewith a series of papers dealing with the dissemination of disease by dairy products and methods for prevention. The first paper, by Dr. G. Lloyd Magruder, a medical specialist of Washington, D. C., who has had an important part in the efforts that have been made for the improvement of the local milk supply, discusses the general subject of milk as a carrier of contagious disease, reviews the history of the movement for a better milk supply for the city of Washington, and points out the desirability of pasteurization. Other papers follow by Doctors John R. Mohler and E. C. Schroeder, of this Bureau, dealing with the significance of the presence of tubercle bacilli and other contaminations in milk, and summarizing and bringing down to date some of their work and observations on these subjects. Messrs. L. A. Rogers and S. H. Ayers, of this Bureau, discuss the interpretation of the results of bacteriological examination of milk. At Doctor Magruder's request, Dr. M. J. Rosenau, formerly director of the Hygienic Laboratory of the United States Public Health and Marine-Hospital Service, has contributed a résumé of his work and views on pasteurization.

Within the last few years there has been great improvement in the direction of obtaining more wholesome and sanitary milk, but much yet remains to be done for the protection of the health of consumers. It is important that there should be not only legislation and competent official supervision, but a better understanding by the producers and the public of the dangers from contaminated dairy products and how these dangers can be avoided and overcome.

The classification of milk recommended by this bureau, as set forth in Circular 114, provides first for clean, raw milk, from healthy, tuberculin-tested cows, drawn and handled in a cleanly manner by healthy attendants, and transported, handled, and delivered to the consumer at a temperature not exceeding 50° F., and within the least possible time. When these conditions can not be met, then pasteurization should be required, under supervision, not for the purpose of making bad milk good, but to render milk of doubtful healthfulness safe. In the milk supply of a large city there will be, for some years at least,

a large proportion of the latter class of milk which must be utilized as food, and this can only be done safely by pasteurization or heating.

Finally, and no less important, milk should be properly handled after its arrival in the home. Great care should be exercised by the housewife and servants to keep milk, meat, and other foods in wholesome condition until they are consumed. A publication on the care of milk in the home is now in preparation.

As the accompanying papers contain much valuable information on the subjects with which they deal, I respectfully recommend their publication as a circular of this bureau.

Respectfully,

A. D. MELVIN,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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By G. LLOYD MAGRUDER, A. M., M. D.,
Emeritus Professor of Materia Medica and Therapeutics, School of Medicine, Georgetown University, Washington, D. C.

INTRODUCTION.

The production, care, and food value of dairy products and their significance as causes and carriers of diseases have been subjects of study for more than twenty years in the city of Washington. This study has extended to milk, cream, ice cream, butter, and cheese. Numerous publications giving the results of these investigations have been issued. They have had a world-wide influence and are often quoted.

Three of the most important of these publications, with the issue of which the writer was intimately associated, are:

1. "Report on Typhoid Fever in the District of Columbia," submitted by the Medical Society of the District of Columbia to the Committee on the District of Columbia of the United States House of Representatives, June 14, 1894, and published by Congress as a congressional document in 1894.

2. "Sanitary Milk Production." Report of a conference appointed by the Commissioners of the District of Columbia. Issued August 20, 1907, by the United States Department of Agriculture as Circular 114 of the Bureau of Animal Industry.

3. "Milk and its Relation to the Public Health," issued in January, 1908, by the United States Treasury Department as Bulletin 41 of the Hygienic Laboratory of the Public Health and Marine-Hospital Service (revised January, 1910, as Bulletin 56).

REPORT ON TYPHOID FEVER IN THE DISTRICT OF COLUMBIA.

The report on typhoid fever was the outcome of the attention that was being called to the high death rate from typhoid in Washington, D. C. On motion of the writer the Medical Society of the District of Columbia appointed a committee, with him as chairman, to investigate the prevalence and causes of the disease. The other members of the committee were Drs. W. W. Johnston and C. M. Hammett.

The report of the committee showed, as the result of investigations which extended over five months, that typhoid prevailed to an alarming extent and that several factors were responsible for its occurrence: (*a*) Potomac water supply; (*b*) pollution of the soil with leakage from privies, from defective sewers, and from backing up of sewage from tidal movements; (*c*) drinking of well or pump water; (*d*) contaminated milk.

Among the recommendations of the committee, which were unanimously adopted by the Medical Society, were the construction of works for the filtration of the Potomac or Washington water—the only method of purification; the abandonment as rapidly as possible of all wells within the city limits; the repairing of defective sewers; the extension of the water supply and the sewers; the making of house connections to the same.

The views of the committee as to the unhealthfulness of well waters were fortified by the results of bacteriological examinations of water from 13 wells in the city of Washington, made by Dr. J. J. Kinyoun. The water from 9 of these wells was classed as bad, and from 2 as suspicious. It was recommended that the 9 wells be closed and that the remaining 4 be kept under observation.

In regard to the milk supply, the committee recommended the "careful inspection of all dairies in the District from which the milk supply is drawn and the enactment of a law by which no milk shall be sold in the District without a permit from the health office. The inspection should cover an examination at the dairies of all possible sources of infection, including the water supply."

It will be seen that pure milk and pure water, both in the city and at the farm, and the avoidance of contact with persons suffering with the disease, were the cardinal preventive measures recommended. The importance of these recommendations was immediately recognized. The United States Congress, as well as the city authorities, sought the aid of the Medical Society and individual members in framing remedial legislation.

That the recommendations made in 1894 were important and proper is attested by remarks made at the symposium on "The causes of typhoid fever in the District of Columbia," held, on motion of the writer, by the Medical Society, February 19 and 26, 1908. Dr. George M. Kober,[a] professor of hygiene, Georgetown University, said that "every point developed in recent discussions, save the influence of domestic filters and water coolers, had received consideration before." Doctor Kober's investigation in 1895 confirmed in every particular the conclusions reached by the committee of the Medical Society in 1894, and developed two new facts, viz, the percentage of imported cases and the agency of flies in the transmission of the disease.

[a] Washington Medical Annals, vol. 7, 1908, pp. 98, 99.

Dr. William C. Woodward, health officer of the District of Columbia, said:[a]

The problem as stated above, "Why is typhoid fever more prevalent in the District of Columbia than in other communities?" was clearly the problem before the Medical Society in 1894, when it inaugurated the campaign against the disease, and the clear realization of the problem to be solved contributed very largely, no doubt, to making the work of that committee as thorough and the results as complete as they were. It may safely be said that, aside from the one or two new facts brought to light by Doctor Kober's investigations, and to which Doctor Kober has already referred, no material fact has been disclosed by any subsequent investigation that was not anticipated in the report of the Medical Society.

The contention for pure water, pure milk, and the avoidance of contact, outlined in 1894, as preventive measures against typhoid fever is further sustained in Bulletin 44 of the United States Public Health and Marine-Hospital Service, May, 1908, as follows (pp. 9 and 10):

Thus far our studies indicate that typhoid fever will cease to be a problem in any community having clean water, an uninfected milk supply, and in which cases of the disease are treated as dangerous and contagious.

In drawing up the conclusions and recommendations of this report we have had the benefit of consultation with the advisory board of the Hygienic Laboratory, composed of eminent scientists and sanitarians. This privilege is appreciated and we desire to acknowledge the help we have received from the members of the board collectively and individually.

THE MILK LAW OF 1895.

The first step toward carrying out the recommendation of the committee of 1894 was the passage of an act by the United States Congress, approved March 2, 1895, which required the inspection of all dairy farms and a permit from the health officer of the District of Columbia before milk could be sold for consumption in the city of Washington. This requirement applied not only to the farms in the District of Columbia, but also to those in the States supplying milk to Washington. This made the city of Washington the first in the country to extend inspection to the dairy farms as well as to the milk depots in the city. The reports of these inspections are now recorded upon cards known as "score cards."

DAIRY INSPECTION IN WASHINGTON AND OTHER CITIES.

The use of score cards has proved to be very popular as well as valuable. Many States and cities have adopted them. The United States Department of Agriculture reports that it has supplied them to about 300 cities in 39 States, and that they are being widely used. These figures, however, do not represent the full extent of the use of the score-card system, as it has been formally adopted by the state health authorities of four or five States and is being introduced by them in

[a] Washington Medical Annals, vol. 7, 1908, p. 103.

the cities under their supervision. The provincial board of health of Ontario, Canada, has recommended its use by all the local boards of health in its jurisdiction. Further, the score card is being used commercially by a number of large wholesale milk dealers for the purpose of ascertaining the methods used among the dairies from which they buy their supplies.

It has been found in many instances that the dairyman upon the second inspection of his dairy has made desirable improvements to secure a higher rating. Many dealers demand a high rating before they will purchase the output of a dairy. As a result of these require-

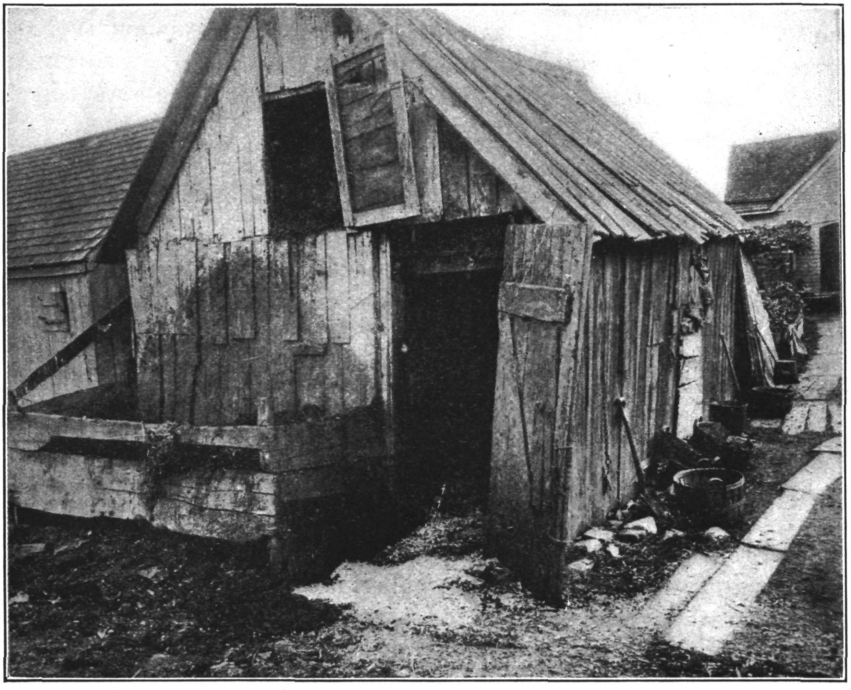

FIG. 1.—Insanitary cow stable. Wholesome milk can not be produced in such a place.

ments much milk is delivered to the distributing depots with less than 2,500 bacteria to the cubic centimeter.

This inspection has revealed many unfavorable conditions both at the farm and at the city depot. Insanitary houses, milk houses, and barns were common. (See figs. 1 and 3.) The attendants upon the cattle were careless of their personal habits and frequently were suffering from disease, sometimes of a contagious character. Cattle were frequently found covered about their flanks, legs, udder, and tail with manure and other dirt, which readily dropped into the pails while milking was being done. (See fig. 5.) Cattle were many times found suffering from constitutional diseases as well as local

affections of the udder. Flies swarmed about the premises. Frequently on the surface of the milk in the pails floated dead and dying flies. With the knowledge now available of the habits of the fly, this condition alone is a most dangerous source of milk infection. The presence of sediment in the milk containers (as shown in fig. 7) was a common occurrence. This is especially dangerous, since it has been shown that the ingredients are pus cells, blood, epithelium, barn-yard manure, and varied bacteria, including colon bacilli, and, as shown by Schroeder and Cotton,[a] very commonly the tubercle bacillus.

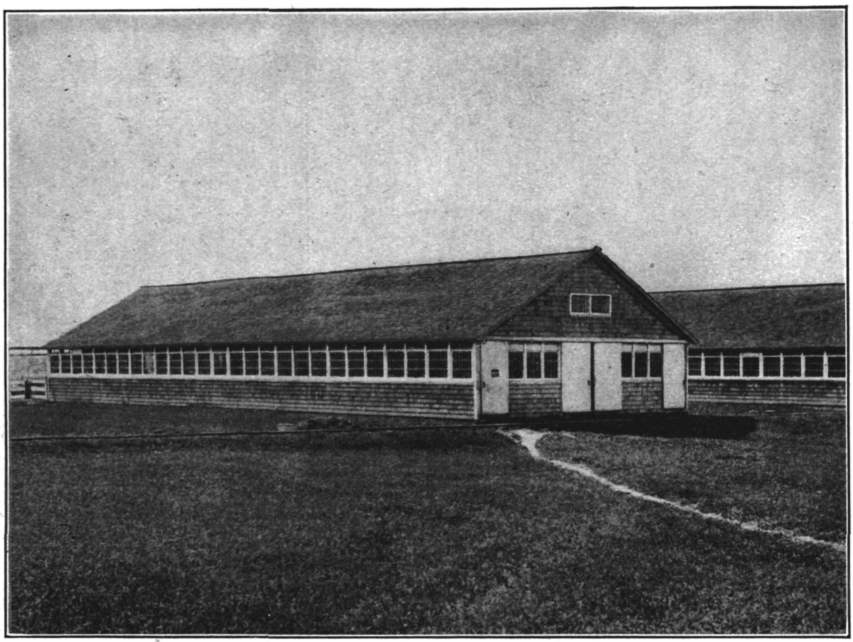

FIG. 2.—An excellent and sanitary dairy barn.

Few if any facilities were found for boiling the water to cleanse the utensils used in the handling and transportation of milk, the hands of the milkers, or the udders of the cows. Polluted water readily contaminates milk. This contamination rapidly multiplies at a temperature above 50° F. The knowledge which is rapidly being accumulated as to chronic carriers of the typhoid bacillus, and the common custom which prevails in rural communities of depositing human excreta upon the ground, frequently in close proximity to residences, barns, and water supplies, demand that the water supply on dairy farms should be frequently examined and carefully guarded

[a] Bulletin 99 and Circular 118, Bureau of Animal Industry, Department of Agriculture.

against contamination. The location of the premises for the storage and the handling of dairy products in the city depots was frequently most objectionable and at times entirely unfit for such purposes.

The following are some results of one year's use of the score-card system of inspection at Indianapolis:

Dairies scored	717
Barns improved	381
New barns built	41
Milk rooms built or repaired	319
Visits made by request to advise about constructing new barns or repairing old ones	137

FIG. 3.—A milk house with insanitary location and surroundings.

The report of the official in charge says:

While at first we met with serious opposition, producer and dealer have become convinced that instead of persecution, the work is for their betterment.

Numbers have thanked us for insisting that they improve their conditions, stating that they do not see how they could have produced milk under the conditions they did.

The records of inspection as kept upon score cards show the result of intelligent inspection of the dairy farms supplying milk to Richmond from May, 1907, to May, 1908. The first inspection in May gave an average of 41.5 out of a possible 100; the inspection in April of the following year, twelve months later, gave an average of 72 for the same premises. This demonstrates a gain of nearly 100 per cent for the year. The improvement was steady throughout this time.

In the annual report of the Richmond, Va., health department for 1908 the dairy inspector in his report to the chief health officer

says: "The disposition among our dairymen to improve their plants is wonderful, and all speak highly of the work of the health department."

Washington City also furnishes an excellent illustration of the effects of intelligent inspection. The inspectors and the producer have learned to understand each other. Many of the farmers welcomed the criticisms and proceeded to remedy these defects, as it was found that much could be done at an insignificant outlay of time and money. Much higher scores were given in many cases upon the second inspection. At the meeting held September 22,

FIG. 4.—A clean and sanitary though inexpensive milk house.

1909, in Washington, of the Milk Producers' Association of Maryland, Virginia, and the District of Columbia, President Thomas in his address reminded the members of the association that "the day was past when the milk inspector was looked upon as an irreconcilable enemy."

Such expressions show the spirit with which intelligent inspection is met. This educational inspection means much to both producer and consumer. It contributes not only to the health of the families of both, but also to that of the dairy herd. It is a well-known fact that typhoid fever prevails to an alarming extent in rural communities. It has been found that it is two and a half times more prevalent in the counties of Maryland than in the city of Baltimore. Tuberculosis is also quite common in the country.

Dr. G. W. Goler, health officer of Rochester, N. Y., has had excellent results from dairy inspection. The death rate of children has been markedly decreased and the prevalence of milk-borne diseases has greatly diminished in that city.

Inspection has worked well; it should be perfected and extended. It should be assumed by state and municipal authorities and not left to the enthusiasm of public-spirited physicians and other citizens. The District of Columbia milk law of 1895 was not entirely satisfactory. Yet it is justifiable to claim that it promptly demonstrated the advisability of municipal and state control. Additional legislation to meet the demands of present-day knowledge is imperative.

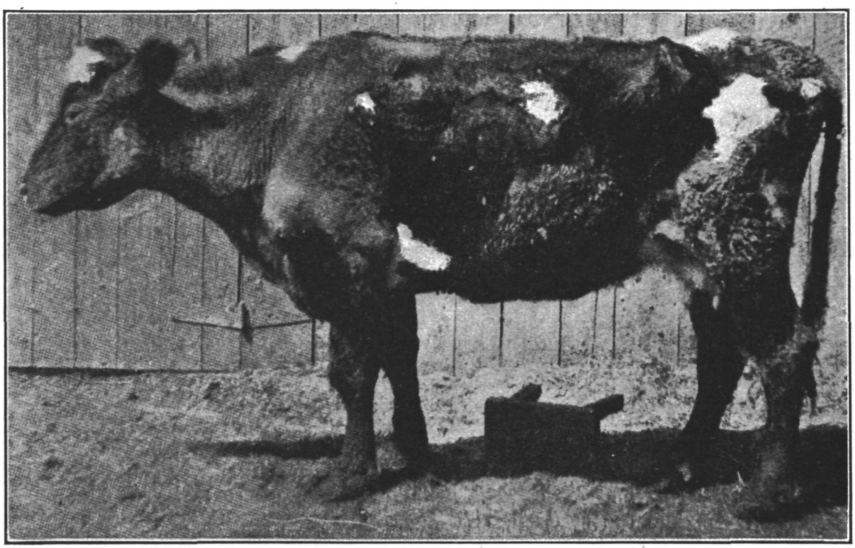

FIG. 5.—A dairy cow in filthy condition.

Dr. W. C. Woodward, health officer of the city of Washington, D. C., in Bulletin 41 of the Public Health and Marine-Hospital Service, says:

> The death rate from diarrheal diseases among infants during the five-year period 1880 to 1884 was 162 per 100,000. During the next five-year period it was 168, and from 1890 to 1894 it was 175. In 1895 the milk law was enacted. From 1895 to 1899 the death rate fell to 135; from 1900 to 1904 it fell to 109, and in 1905 it was only 104, and in 1906, 1907, and 1908 only 97 per 100,000. [In 1909 it fell to 72.]

The diagram that accompanies Doctor Woodward's article (here reproduced as fig. 9) shows the above facts graphically.

THE EFFECT OF WATER FILTRATION ON TYPHOID INCIDENCE.

An important advance toward carrying out the recommendations of the report of 1894 was the completion of the filtration plant in 1905 for the Washington water supply. The efficiency of this plant has eliminated the water as a factor in the causation of typhoid fever. The reports of the engineer officers in charge show the following results:

Results of tests for Bacillus coli of 10 and 1 c. c. samples from filtered water reservoir and tap water from various parts of city.

Fiscal year.	Number samples examined.	Samples in which *B. coli* was positvely determined.	
		Number.	Percentage.
1905–6	502	8	1.60
1906–7	1,630	52	3.18
1907–8	2,232	42	1.88
1908–9	2,294	15	0.67
1909–10[a]	940	0	0.00

[a] Five months only, July to November, 1909, inclusive.

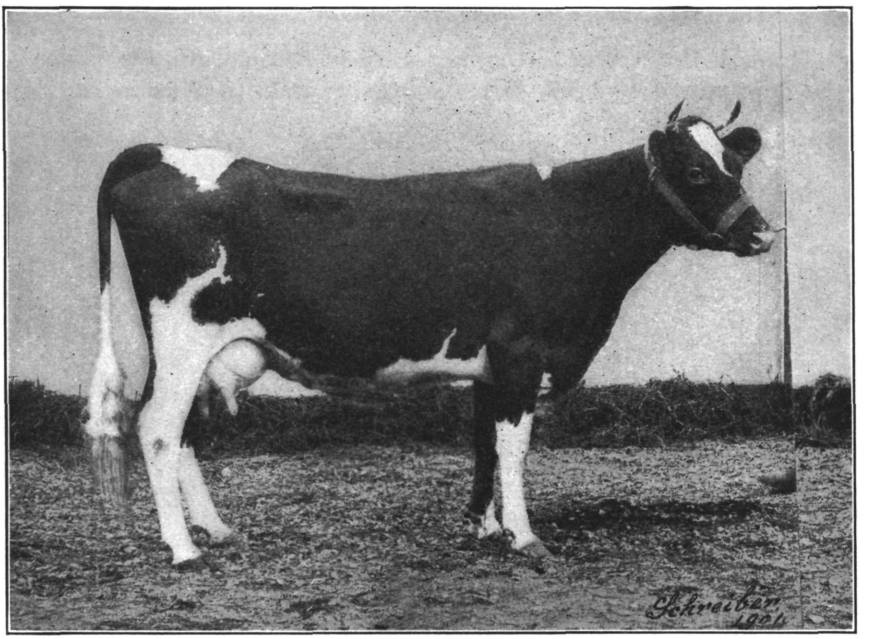

FIG. 6.—A fine dairy cow in good, clean condition.

The results of similar tests of unfiltered water for five months of 1909 showed that 28 out of 549 samples positively contained *B. coli*.

These results are confirmed by the series of check experiments conducted during September, October, and November, 1906, by the Bureau of Plant Industry of the Department of Agriculture, and those in charge of the filtration plant, and by repeated examinations by the Bureau of Chemistry of the Department of Agriculture, the Geological Survey, and the Hygienic Laboratory of the Public Health and Marine-Hospital Service. Washington can now use without fear water direct from the faucet. The occasional turbidity could easily be eliminated by providing for preliminary treatment during these times. This preliminary treatment would in nowise exert any dele-

terious influence. There is no need to resort to boiling the Potomac water nor to the use of bottled waters of questionable purity.

Contrary to every expectation, there was no diminution in the prevalence of typhoid fever following the completion of the filtration plant as compared with the few preceding years. Numerous investigations were undertaken and reports made; some covered conditions in the city, and others covered both the city and the dairy farms. Continued study convinced the writer that stricter attention must be paid to the conditions at the dairy farms, including their water supply, to which he had called attention in 1894.

INVESTIGATION OF WATER SUPPLIES OF DAIRY FARMS.

Through the efforts of the Secretary of Agriculture, every one of the approximately 1,000 farms supplying milk to Washington was

FIG. 7.—Dirty sediment in bottom of bottle of milk.

inspected by the Bureau of Animal Industry in the winter of 1906–7. The average score of these farms was as low as 45.03 out of a possible 100. On 60 of the farms, taken at random, bacteriological investigations of the springs and wells were made by the Bureau of Plant Industry. These were the first on record of an extended series of investigations of their kind.[a] Doctor Kinyoun did make 6 such examinations in 1895, in 4 of which he found the water supply to be contaminated. Previously the analysis of waters was only chemical. The revelations were startling. Subsequently 290 more water supplies were examined by Dr. B. M. Bolton of the Bureau of Animal Industry, with equally astounding results.

[a] Kellerman, Karl F. Bacteria of the dairy wells in the vicinity of Washington, D. C. Washington Medical Annals, vol. 6, 1907, p. 83.

The bacteriological examinations of the water supplies of the first 60 dairy farms showed that only 25 per cent were under the danger line—that is, if we take 500 bacteria to the cubic centimeter of water as the limit of safety; 30 per cent were suspicious, having above 500 bacteria to the cubic centimeter, and 45 per cent were positively unfit for use, as they showed the presence of sewage bacteria. The bacterial counts in some instances were as high as 27,000, though they were made in November and December—that is, in comparatively cold weather.

Since these bacteriological examinations were made similar examinations have followed in other cities and States, with almost identical

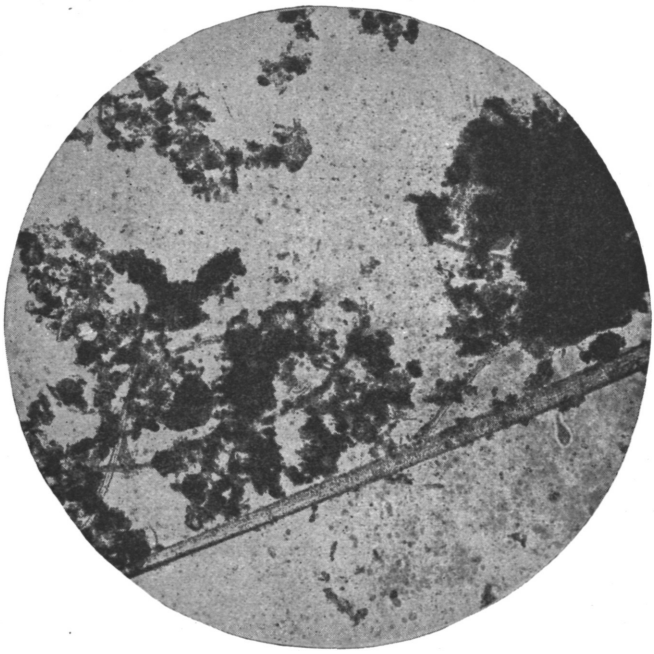

FIG. 8.—Milk sediment magnified. This sediment consists of cow dung, hair, bacteria, etc.

results. Up to August, 1908, 386 such examinations had been made on the dairy farms around Chicago. Doctor Evans, the health officer, was so impressed with the bad conditions that he decided to continue the investigations. Professor Prescott, associated with Professor Sedgwick, reported upon 240 farms in Massachusetts. While the tests showed far better conditions than those in other States, enough information as to bad conditions was obtained to warrant Professor Prescott in recommending these examinations to be made annually. Bulletin 154 of the Bureau of Plant Industry, United States Department of Agriculture, by Kellerman and Whittaker, issued November 6, 1909, gives the results of the examination of the water supplies of 79 farms in Minnesota. Twenty were found to be good, and 59 were

polluted, 23 of the farms examined showing a record of typhoid fever. On 5 of them the water was not polluted, on the other 18 the water was polluted.

These records support the contention for the necessity of bacteriological examinations of these water supplies. Impressed with these revelations, Dr. M. P. Ravenel has urged the inspection of the water supplies of all farms in Wisconsin. It is expected that many other examinations will be made in the near future.

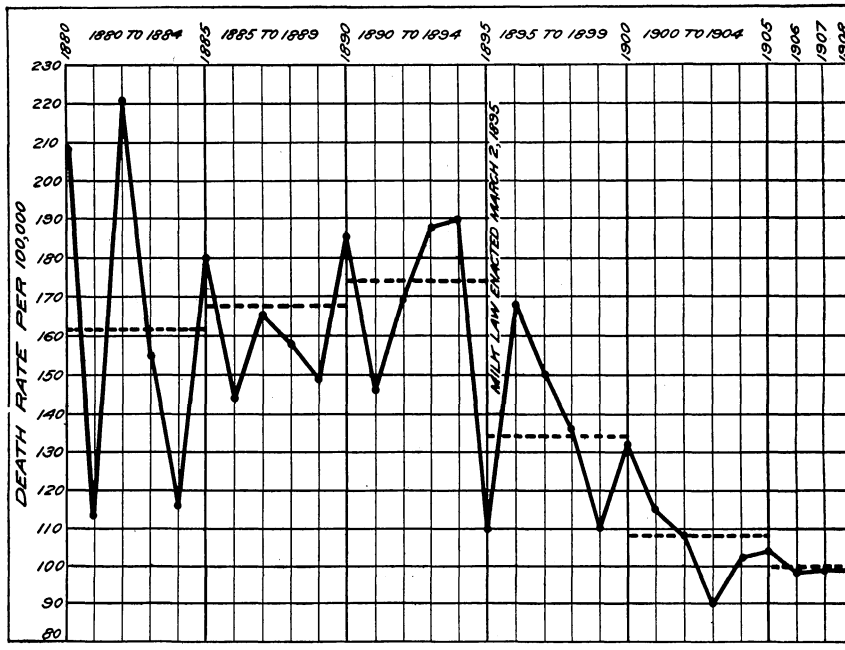

FIG. 9.—Diagram showing decrease in death rate of children in the District of Columbia following the enactment of the milk law of 1895. Dotted lines show averages. (In 1909 the death rate fell to 72.)

THE WASHINGTON MILK CONFERENCE.

The conditions on dairy farms supplying milk to the city of Washington were brought to the attention of the Commissioners of the District of Columbia, and the result was the appointment of the Washington milk conference, a report of which was published as Circular 114 of the Bureau of Animal Industry, before referred to.

This circular shows the dangers of raw milk and the value of pasteurization. The following abstract in an editorial published in the London Lancet [a] gives a very excellent idea of some of the features of this report:

The Agricultural Department at Washington has issued a volume of reports containing the results of the conference of experts called together by the department to con-

[a] The Lancet, Vol. II, 1907, No. XIII (Vol. CLXXIII, No. 4387), pp. 936, 937.

sider the various questions now agitating the country in regard to the purity of the milk supply. The conference consisted of 35 recognized experts in the study of the questions involved. This volume will be the recognized text-book of the health authorities of this country for the present, as it carries the weight of authority of these experts and the indorsement of the Department of Agriculture. In brief, these experts agreed upon a definite milk programme and have recommended that public safety should be assured by legislation establishing three classes or grades of milk—namely, certified, inspected, and pasteurized. They would not tolerate any trifling with the public in the sale of so-called certified milk. They would require that such milk should come from dairies subject to periodical inspection and that the milk should be frequently analyzed; that the cows should be proved to be free from tuberculosis by the tuberculin test and from all other communicable diseases; that the milk should be handled by persons free from infection; that the milk should contain not more than 10,000 bacteria to the cubic centimeter; and that it should not be more than twelve hours old when delivered to the consumer. The conference would permit the sale of such milk raw under the label "certified," and would allow the sale raw, under the label "inspected," of milk that had been similarly produced but did not quite come up to the requirements for certification, provided that such milk came in all cases from tuberculin-tested cows and did not contain more than 100,000 bacteria to the cubic centimeter. Such milk, and only such, do these experts believe should be sold raw; all other milk should be pasteurized. The declaration of the conference is as follows: "Milk from the dairies not able to comply with the requirements specified for the production of milk of classes 1 [certified] and 2 [inspected] is to be pasteurized before being sold," and then sold under the designation "pasteurized milk." All milk of an unknown origin shall be placed in class 3 and shall be subjected to clarification and pasteurization at central pasteurization plants which shall be under the personal supervision of officers of the health department. The term "pasteurization" is explained to mean the heating of the milk to a temperature of 150° F. for twenty minutes, or 160° for ten minutes, and immediate cooling to 50°.

The writer was so impressed with the reception and the influence for good of the report of the Washington milk conference that in June, 1907, he suggested to Mr. Roosevelt, then President of the United States, both at a personal interview and in the following letter, that an investigation be made of the milk industry from the farm to the consumer.

WASHINGTON, D. C., *June 11, 1907.*

SIR: In view of the agitation that is now going on in Europe and this country with reference to the question of the influence of milk upon infant mortality, as well as the causation of tuberculosis, typhoid and scarlet fevers, and diphtheria, I would respectfully suggest that you direct the Bureau of Public Health and Marine-Hospital Service to make a thorough investigation of the milk industry in the District of Columbia from the farm to the consumer. For this purpose the Bureau should be empowered to have the cooperation of other departments of the Government, and proper credit should be given for such aid.

Several foreign governments have recently ordered such investigations, and the reports are frequently quoted by writers in the United States upon these subjects. These writers have expressed many divergent views.

The recent investigation conducted by the Bureau of Public Health and Marine-Hospital Service into the cause of the prevalence of typhoid fever in the District of Columbia, which report, including an examination of the milk supply in the city of Washington, has been printed and will be issued in a few days, and the work of the Department of Agriculture concerning the milk supply at the farms have shown that

many lives could have been saved and numerous cases of disease avoided by more careful attention to the health of the dairyman as well as the cows, and the handling of the milk at the farm, in transportation, and distribution in the city.

Much valuable information has been accumulated by both departments, which can be consolidated and developed so as to be utilized as a standard not only for the District of Columbia, but for the United States. This standard is very essential at the present time, and, with the facilities at the disposal of the United States Government, should have equal weight with that of any other government.

It can be readily shown that much can be done to improve the milk supply without materially adding to the cost to the farmer and thus to the consumer.

The report of such an investigation should be freely illustrated that it may serve as an educational document.

Very respectfully, yours, G. LLOYD MAGRUDER, M. D.

The PRESIDENT.

President Roosevelt grasped the importance of the subject and immediately directed an investigation, which was conducted by recognized experts in the United States Department of Agriculture, the United States Public Health and Marine-Hospital Service of the Treasury Department, and Dr. W. C. Woodward, health officer of the District of Columbia. The report of the various experts who elaborated the work of the Washington milk conference is published as Bulletin 41 of the Public Health and Marine-Hospital Service, and is widely recognized as the most valuable work ever issued by the United States Government on public health. In it all the views advanced by the Washington milk conference are positively indorsed.

EPIDEMICS TRACED TO THE MILK SUPPLY.

In May, 1901, Dr. George M. Kober reported a series of 330 outbreaks of infectious diseases that were spread through the milk supply. These outbreaks consisted of 195 epidemics of typhoid fever, 99 of scarlet fever, and 35 of diphtheria. In 148 of the 195 epidemics of typhoid fever there is evidence of the disease existing at the farm.

Kober says:

It is interesting to note that of the 330 epidemics analyzed by me, 243 have been recorded by English authors, 52 by American, 14 by German, 11 by Scandinavian, and 5 each by French and Australian writers. This is probably due to the fact that the English and Americans usually consume raw milk, while on the Continent the milk is rarely used without being boiled.

Surgeon Trask, of the United States Public Health and Marine-Hospital Service, in Bulletin 41, has added a large number of similar outbreaks to Doctor Kober's list.

The occurrence of over 600 cases of streptococcus sore throat in Stockholm in the early part of 1908 was traced to a streptococcus abscess in the udder of a cow in a herd that furnished milk to those who became infected. The significance of streptococci in market milk requires careful and immediate investigation.

In the fall of 1908 over 50 cases of typhoid fever in Washington, D. C., were traced to the supply of milk from a single farm. The owner was a bacillus carrier. The supply of milk from this farm was stopped.

From the well-known prevalence of rural typhoid, the presence of bacillus carriers, and the existence of contaminated water supplies at many farms which can readily contaminate milk, it seems that milk is a far greater factor in keeping up the typhoid rate in Washington than a number of writers have been willing to admit. The writer has always contended that dairy products were the principal sources of the disease. In view of recent investigations, he reasserts his position.

The recent outbreak of typhoid fever in August, 1909, in Cassel, Germany, is a striking example of the results of contaminated milk. The circumstances were stated by Mr. E. Berliner in a paper read before the District of Columbia Association for the Prevention of Tuberculosis, as follows:

In the latter part of August of this year several cases of typhoid fever made their appearance in a home for babies, but, strange to say, the fever did not attack the children but several of the nurses, and it was soon ascertained that the milk consumed in the home had been partaken of in a raw state by the nurses, but by the children only after having been scalded. In the meantime typhoid cases were reported from all over the city, and the wide-awake health officer of Cassel, Privy Medical Counsellor Doctor Heinemann, soon discovered that in every instance the families in which the fever developed obtained their milk from one and the same dairy, the "Sanitäts Mölkerei," which distributed about 7,000 liters per day. This dairy was kept scrupulously clean and was looked upon as a model of its kind, with the cognomen "Sanitary" attached to its name as a catchy advertisement. The dairy received its milk from over 30 farms, but had never paid much attention to inspection or to bacteriological tests. When the typhoid outbreak assumed the aspect of an epidemic, Doctor Heinemann ordered the "Mölkerei" closed and publicly advised the inhabitants of Cassel to drink only scalded milk. But for many unfortunate citizens the advice came too late, and over 300 cases, with the usual mortality, resulted from the drinking of the infected milk in the raw state.

And here a deplorable misconstruction of Doctor Koch's attitude toward the question of bovine tuberculosis, as affecting human beings, should be mentioned. A prominent sanitarian in Cassel told me that whereas formerly everybody in Germany drank his milk scalded or boiled, many now drank it in the raw state because, with Koch's defense of milk from tuberculous cows and the persistent opposition of many physicians to pasteurization for theoretical reasons, raw milk is by many hailed as the model food for man, woman, and child. And those ill-starred citizens whose vitality was already low and who would therefore constitute a most excellent soil for the development of milk-bred diseases, would fall ready victims to one of the most dangerous and death-dealing theories which by, or with the sanction of, medical men was ever offered to a confiding humanity. Doctor Heinemann found that in every case it was only those members of the household who had partaken of "Mölkerei" milk in the raw state who became sick, while all the others who drank the milk scalded or boiled remained entirely well.

And now as to the primary cause of the epidemic. The different farms which supplied the "Mölkerei" with milk were investigated. Doctor Heinemann's medical

agents found no typhoid cases on the premises, nor did they take the time to search for chronic bacilli carriers, but they did find the wells on several of the farms in most suspicious condition, and, furthermore, that water from streams, polluted by human settlements for long distances, had in some cases been used for rinsing the milk cans. Whosoever has studied dairy conditions in Germany and knows of the untold filth on the farms, the dirty stables and yards, and the ignorance and the apathy regarding sanitation, not only among the peasants but even among some of the very best classes of people, does not wonder at such an epidemic, but rather that there are not many more similar ones. No doubt there are, but they do not become known, the knowledge of them being withheld by jealous municipalities.

I asked Doctor Heinemann what he proposed to do to prevent further troubles. He said that the "Sanitäts Mölkerei" was still closed and would not reopen until an up-to-date pasteurization plant had been installed. They would also introduce a system of sterilizing all milk cans from the farms with live steam, and send them back sealed, and they are to remain sealed until refilling time—an excellent idea.

Though the cattle of America are not as commonly affected with tuberculosis as those of Europe, the Bureau of Animal Industry of the United States Department of Agriculture reports that 33 per cent of the centrifuge slime examined at public creameries showed tubercle bacilli. This fact, in view of the publications of Schroeder and others, showing that tubercle bacilli rise in milk as freely with the cream as they sink with the sediment, is of great importance.

The significance and the effect of the presence of tubercle bacilli in dairy products have deeply interested investigators in many countries. The British Royal Commission on Human and Animal Tuberculosis takes the position that bovine tuberculosis is a positive factor in causing tuberculosis in human beings, and its "Third Interim Report," London, 1909, is mainly a repetition and a confirmation of the work done by Dr. E. C. Schroeder and Mr. W. E. Cotton, of the Bureau of Animal Industry, in 1906 and 1907. (See Bulletin 99, and Circular 118, Bureau of Animal Industry.)

BRITISH TUBERCULOSIS REGULATIONS.

In view of the above-mentioned report by the British Royal Commission, the Board of Agriculture and Fisheries of Great Britain have issued the "Tuberculosis Order of 1909," dated May 27, 1909, from which the following is taken:

1. I am directed by the board of agriculture and fisheries to send to you for submission to your local authority the inclosed copy of the tuberculosis order of 1909, which will come into operation on the 1st of January, 1910.

2. As your local authority are doubtless aware, the subject of tuberculosis in man and in animals, and the relations between the disease in human beings and in animals, has been under careful investigation during recent years in this country and abroad, and various phases of the question have been inquired into by successive royal commissions. So far as regards the possibility of the transmission of the disease from affected bovine animals to man, the board are satisfied that it must now be accepted as a fact that tuberculosis is transmissible by the agency of milk used for human consumption. The local government board concur in this view, and a bill was introduced in the House

of Commons by the president of the local government board on the 25th instant designed, inter alia, to afford protection to the public health from the risk of the spread of tuberculosis by the means of milk used for human consumption.

3. In considering the question in relation to animals, the fact that the disease is communicable to man by milk has a material bearing on the measures to be adopted. Any action which results in the reduction in the number of tuberculous bovine animals in the country must reduce the risk of the spread of tuberculosis amongst the community, and if it were possible to eradicate from this country the disease in animals, a material step forward would have been taken in the campaign against the disease in man.

PASTEURIZATION AS A SAFEGUARD.

Even though the danger of contracting tuberculosis from dairy products can be eliminated if we can obtain milk from healthy cows, there still remains the danger of contracting other diseases from contaminated milk. Milk can be made safe, however, by the proper application of heat. There are two terms applied to the results of heating milk, pasteurization and sterilization. These two terms must not be confounded; the former is a process that requires the application of a much lower degree of heat than is effective for the latter. Sterilization means the killing of all the germs that may be present in milk. Pasteurization means the destruction of the disease germs that are of more common occurrence in it, such as those of tuberculosis, typhoid fever, diphtheria, etc. The investigations of Dr. M. J. Rosenau especially have shown that the common or pathogenic bacteria are unable to retain their life and virulence when they are exposed to a temperature of 60° C. or 140° F. for a period of twenty minutes, and that the value of milk as an article of food is not perceptibly affected by the designated temperature. Professor Kastle, of the University of Virginia, after extensive investigation, concluded that the designated temperature, maintained for a sufficient time to destroy the disease germs of common occurrence in milk, has no deleterious effect on its nutritive value. Thousands of children under the eyes of careful and competent observers have been reared successfully upon milk so treated without the slightest signs of scurvy or rickets. The temperature required for sterilization does destroy the enzyms and impair the nutritive value of milk. This emphasizes the necessity for a proper appreciation of the processes, pasteurization and sterilization.

It must be kept in mind that the advocates of pasteurization do not countenance the use of unclean or old milk; on the contrary, they insist that pasteurization should be applied, not to correct sensible conditions of an objectionable character, but simply as a measure of safety against the dangers from milk which no other precautions can obviate. Furthermore, pasteurization should be practiced under proper supervision, and that form of so-called pasteurization which is to some extent commercially practiced, during which

milk is heated to an unnecessarily high temperature for barely a fraction of a minute, should be emphatically discountenanced. Health officers should be provided with properly equipped laboratories to keep constant check upon the output of pasteurizing plants. Progressive men in the distribution of milk, cream, and ice cream employ skilled bacteriologists. All milk, whether pasteurized or not, should be consumed as soon as possible after milking.

It frequently happens that properly pasteurized milk can not be secured on the market. The observance of the following directions

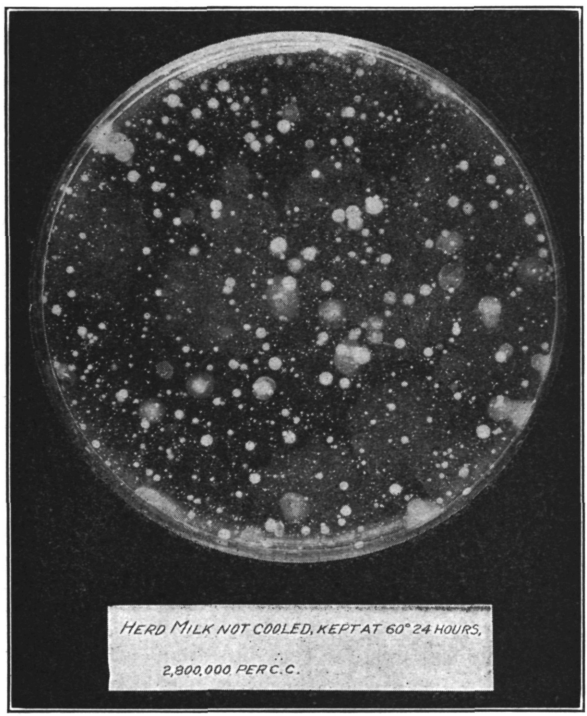

FIG. 10.—Culture plate showing bacteria in milk not cooled, kept at 60° F. for twenty-four hours. Numerous colonies; 2,800,000 bacteria per cubic centimeter.

for the home pasteurization of milk, by L. A. Rogers,[a] of the Bureau of Animal Industry, can then be practiced:

Milk is most conveniently pasteurized in the bottles in which it is delivered. To do this use a small pail with a perforated false bottom. An inverted pie tin with a few holes punched in it will answer this purpose. This will raise the bottles from the bottom of the pail, thus allowing a free circulation of water and preventing bumping of the bottles. Punch a hole through the cap of one of the bottles and insert a thermometer. The ordinary floating type of thermometer is likely to be inaccurate, and if possible a good thermometer with the scale etched on the glass should be used. Set the bottles of milk in the pail and fill the pail with water nearly to the

[a] Circular 152, Bureau of Animal Industry, Department of Agriculture.

level of the milk. Put the pail on the stove or over a gas flame and heat it until the thermometer in the milk shows not less than 150° nor more than 155° F. The bottles should then be removed from the water and allowed to stand from twenty to thirty minutes. The temperature will fall slowly, but may be held more uniformly by covering the bottles with a towel. The punctured cap should be replaced with a new one, or the bottle should be covered with an inverted cup.

After the milk has been held as directed it should be cooled as quickly and as much as possible by setting in water. To avoid danger of breaking the bottle by too sudden change of temperature, this water should be warm at first. Replace the warm water slowly with cold water. After cooling, milk should in all cases be held at the lowest available temperature.

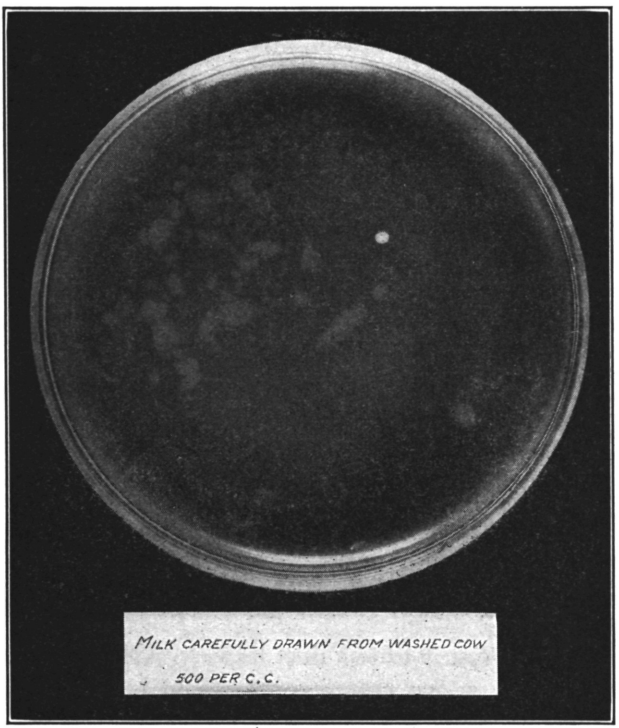

FIG. 11.—Culture plate from milk carefully drawn from washed cow and handled in a sanitary manner. Only a single colony, and but 500 bacteria per cubic centimeter.

This method may be employed to retard the souring of milk or cream for ordinary uses. It should be remembered, however, that pasteurization does not destroy all bacteria in milk, and after pasteurization it should be kept cold and used as soon as possible. Cream does not rise as rapidly or separate as completely in pasteurized milk as in raw milk.

THE IMPORTANCE OF KEEPING MILK COOL.

The cooling of milk and keeping it at a temperature not above 50° F., both at the farm and until used, is as important as raising it to a proper temperature for pasteurization. The importance of cleanli-

ness and cooling is well illustrated by figures 10 and 11. It is well known that the colon and typhoid bacilli, as well as other bacteria, proliferate rapidly in milk as soon as the temperature rises above the 50° F. line. This fact helps to explain the greater prevalence of typhoid fever in winter in localities where the temperature goes above 50° F. for any prolonged period, as few milk producers and dealers use ice to keep milk cool during the winter months.

The winter of 1889–90 was the warmest known in Washington for fifty years. The winter of 1908–9 was also unusually warm. The Weather Bureau of the United States Department of Agriculture reports the mean temperatures for these seasons, together with the normal temperature, for comparison, as follows:

Temperatures at Washington, D. C., for periods shown.

Data.	December.	January.	February.
	°F.	°F.	°F.
Mean temperature, 1889–90	45.6	43.8	43.4
Mean temperature, 1908–9	36.8	36.0	43.0
Normal temperature (33 years)	36.1	32.9	34.5

Typhoid fever prevailed to a marked extent during both of these seasons. But little, if any, ice formed in the vicinity of Washington. In every other year ice 4 inches thick could have been harvested.

CONCLUSION.

If the lessons taught by these observations be heeded, a great step will be made toward the control of milk-borne infections. Dollars spent by the thousand for prevention will save millions needed for the care of those afflicted with disease, to say nothing of the days of suffering that will be avoided.

It can no longer be doubted that dairy products—and this term includes milk, cream, ice cream, butter and cheese—are excellent culture media for pathogenic bacteria. Outbreaks of typhoid fever, scarlet fever, diphtheria, sore throat, and intestinal disorders of children have been definitely traced to contaminated milk. The proofs of the danger from tubercular infection of these products are accumulating daily. The opportunities for such infection are manifold. With the greatest vigilance on the part of trained inspectors and the greatest care on the part of the householder this infection can not be entirely prevented. The householder also has a duty to perform to protect milk from contamination after it has been delivered.

Of course the carrying out of the recommendations for the production and delivery of more sanitary milk entails additional expense at the farm and the city depot. But the receipt of a single additional cent for a quart of milk would justify many improvements by the

producer and the seller. A single case of sickness or a funeral resulting from contaminated milk would cost far more than the slight additional price of better milk for a long period.

Under these circumstances there should be no question about demanding that milk should be produced under conditions that would entitle it to be entered under class 1 (certified milk) or class 2 (inspected milk) as prescribed by the Washington milk conference, or, in case it does not conform to the requirements for these classes, that it should be efficiently pasteurized (class 3).[a] To produce milk under any of these classes rigid inspection is required.

The prices that must be charged for the first class make it almost impossible for the man of moderate means to avail himself of such milk. Class 2 can be produced at a lower price, but would still cost more than ordinary milk. Hence the masses must resort to the milk of class 3. With the precautions suggested, they would reasonably be assured in the use of this milk of a safe and wholesome supply at but a trifling advance in the price.

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[a] This classification, prepared by Dr. A. D. Melvin, Chief of the Bureau of Animal Industry, and approved by the Washington milk conference, is more fully described in Circular 114 of the Bureau of Animal Industry.

II. THE IMPORTANCE OF A WHOLESOME MILK SUPPLY.

By JOHN R. MOHLER, V. M. D.,
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INTRODUCTION.

The reasons for securing a supply of pure and wholesome milk are so numerous and so important that the public should become acquainted with some of the more essential of them in order that assistance may be rendered in bringing about a satisfactory improvement. Public health demands the purity of all milk and milk products. Next to bread, milk is more extensively used as an article of diet than any other foodstuff. It forms a portion of the food of almost every person on practically every day of the year. Furthermore, unlike many other articles of diet, milk is consumed in most cases in an uncooked state, making it a very dangerous food should it perchance contain any deleterious organisms. Not only is milk a very suitable medium for almost every description of germ life which may gain access to it in its journey from the cow to the consumer, but it may also become contaminated while still in the udder through infectious or poisonous material present in the cow herself. In this paper, however, consideration will be given only to the latter aspect of the subject.

In this connection it will be necessary to keep in mind the requirements of an awakened public for a clean and wholesome milk, as well as the effect of any unreasonable or irrational demand upon the producer, which may cause him heavy losses or even to discontinue his business. It will also be apparent that in order to produce milk in compliance with the requirements hereafter described certain precautions must be taken, which will necessarily entail additional expense upon the producer of this higher grade of milk. The customer must therefore expect to pay his portion of any legitimate advance in the cost of production, and such increase in the price of milk due to its improved quality should be considered as money well expended.

Moreover, good milk of safe quality can not be had without a realization on the part of the farmer, the transportation agent, the dairyman, and the housewife of the danger in utilizing old, warm, or dirty milk. Education is therefore an important factor in the improvement of the milk supply, which can not be accomplished through laws and regulations alone. In view of these facts, it is recommended that the subject be taught in the schools, that popular

articles be frequently prepared for the press, that lectures and demonstrations be given in towns and townships, that pamphlets in plain language be prepared by the health officer for general distribution, and especially that rules and suggestions, with reasons therefor, be placed in the homes of dairymen and dairy attendants.

TUBERCULOSIS.

Tuberculosis is probably the most important disease of cows from the standpoint of public health, and it is also the most prevalent. When Koch first discovered the cause of tuberculosis and combined the announcement of his discovery with the statement that he considered the affection identical in both man and cattle, this view was accepted by scientists as well as by the general public. His subsequent announcement in 1901 to the effect that this disease was different in man and in cattle, and that there was no practical need for preventing the use of the products of tuberculous animals for human food, was the cause of much rejoicing among those who were only too glad to grasp at any idea which would tend to separate the disease in man and in cattle, forgetting that bovine tuberculosis is also a dangerous disease to other cattle in the herd, and should be stamped out for this reason aside from any danger to man.

As a result of this radical statement of Koch's, which was based upon incomplete and unsatisfactory evidence, several government commissions were appointed in different countries, and many private and public scientists immediately took it upon themselves to solve the question raised by that investigator. The results of these experiments were so strikingly similar that it is now the generally accepted opinion among scientists that people, especially children, may become infected with tuberculosis from cattle. It is not known to what extent such infection occurs, nor is it possible to obtain any definite percentage by the method formerly adopted of looking for the primary lesions in the intestinal canal, although much statistical evidence is recorded, showing that even by these figures primary intestinal tuberculosis of children has been observed in from 2 per cent (Bovaird) to as high as 45.5 per cent (Heller) of the tuberculous cases examined. Evidence which must be considered conclusive has been obtained by the Bureau of Animal Industry, as well as by Ravenel and a number of French investigators, showing that tuberculous infection may take place through the intestinal tract without leaving any lesion in the abdominal cavity, the first alteration being found in the lungs or the thoracic glands. Therefore the presence of pulmonary tuberculosis in infants without intestinal lesions is no indication that the disease was not transmitted by the food, and the statistics above referred to are thus shown to be below the true percentage of cases of tuberculosis of intestinal origin.

EVIDENCE OF TRANSMISSION FROM CATTLE TO PEOPLE.

These figures, however, do not give any satisfactory idea as to whether the bacilli entering the intestines originated from human or bovine sources. Owing to this fact it follows that the only way of determining the infection of people by bacilli of the bovine type is to study the lesions in the body of as many cases of human tuberculosis as possible. Already we have sufficient data to give us some idea of the extent of tuberculosis of the bovine type in children, without considering the numerous cases of direct transmission recorded by many physicians, especially of instances of butchers and others receiving accidental infections of the skin with the bovine organism. Moreover, according to Von Behring, the question of infection in man usually goes back to childhood, as he believes that many of the cases of pulmonary tuberculosis in adults are of intestinal origin, infection having occurred primarily through the intestinal tract by drinking tuberculous milk during infancy and having remained latent until adult life. As vital statistics show that 14 out of every 100 people that die succumb to tuberculosis, while of the remaining 86 more than one-half show lesions of tuberculosis on post-mortem, although dying from some other cause, the foregoing statement of Von Behring is also practically pertinent in regard to the relation of human tuberculosis to the milk supply, especially in connection with the results of those investigators who have studied market milk and found from 2.7 to 55 per cent of the samples examined to contain tubercle bacilli.

Since direct experiments upon human beings are out of the question, the finding of the bovine type of tubercle bacillus in human lesions is the most direct and positive proof that tuberculosis of cattle is responsible for a certain amount of tuberculosis in the human family. Numerous experiments with this object in view have already proved this fact. Thus, the German Commission on Tuberculosis examined 56 different cultures of tubercle bacilli of human origin and found 6 which were more virulent than is usual for human tubercle bacilli, causing marked lesions of tuberculosis in the cattle inoculated with them, and making over 10 per cent of the cases tested that were affected with a form of tuberculosis which, by Koch's own method, must be classified as of bovine origin. The bacilli, with the exception of a single group, were all derived from the bodies of children under 7 years of age, being taken from tuberculous ulcers in the intestines, the mesenteric glands, or from the lungs.

In a similar series of tests conducted by the British Royal Commission on Tuberculosis, 60 cases of the disease in the human were tested, with the result that 14 cases were claimed by this commission to have been infected from bovine sources. Ravenel reports that of 5

cases of tuberculosis in children 2 received their infection from cattle. Theobald Smith isolated bovine bacilli in 12 out of 28 tuberculous cervical lymph glands and in 1 case of tuberculous meningitis. He estimates that from 25 to 50 per cent of the cases of human tuberculosis starting in the cervical and mesenteric lymph glands are bovine in origin. Park has recently found 6 cases of bovine infection out of 35 cases of generalized tuberculosis of infants, and 10 cases due to the bovine type of bacillus out of 35 cases of surgical tuberculosis, or altogether about 23 per cent of these cases in children due to bovine infection. Of 4 cases of generalized tuberculosis in children examined in the Biochemic Division of the Bureau of Animal Industry 2 were found to be affected with very virulent organisms, which warranted the conclusion that such children had been infected from a bovine source. The Pathological Division of the same bureau has likewise, out of the 9 cases of infantile tuberculosis examined, obtained 2 cultures of tubercle bacilli that could not be differentiated from bovine cultures. In Europe so many similar instances of bovine tubercle bacilli having been recovered from human tissues are on record that it appears entirely proved that man is susceptible to tuberculosis caused by animal infections, and while the proportion of such cases can not be decided with even approximate accuracy, it is nevertheless incumbent upon us to recommend such measures as will guard against these sources of danger.[a]

MILK AS A CARRIER OF TUBERCULAR INFECTION.

The two principal sources of infection from cattle, and the only ones necessary to be considered, are the meat and the milk of tuberculous animals. The fact that most of the cases of bovine tuberculosis above enumerated which were found in the human occurred in infants points with grave suspicion to the milk rather than the meat supply. This naturally leads to the question of how and under what conditions does the milk become dangerous, since Bang, Rabinowitsch and Kempner, Ernst, Ravenel, Smith, MacWeeney, Moussu, Gehrmann and Evans, Mohler, and many others have definitely determined the infectiveness of milk from tuberculous cows.

That milk coming from a tuberculous udder is capable of transmitting the infectious principle is conceded by all who have given the subject any consideration. It has been equally established that in advanced generalized tuberculosis the udder may eliminate tubercle bacilli without showing any indication of being affected. Careful experiments performed by trained and eminently responsible inves-

[a] Ravenel has collected the number of cases of human tuberculosis which have been studied with special reference to the type of bacillus causing them, whether human or bovine, and states that of the 306 cases reported, 63, or approximately 20 per cent, were due to the bovine tubercle bacillus.

tigators have also demonstrated beyond reasonable doubt that tubercle bacilli at certain times may be present in the milk of cows which are affected with tuberculosis to such a degree that the disease can be detected only by the tuberculin test, so that in a herd of cows in the various stages of tuberculosis it is to be expected that some of them will secrete tuberculous milk, which, when mixed with other cows' milk, makes the entire product dangerous.

In this connection it may be stated that the market milk of the District of Columbia has recently been examined by the writer for the presence of tubercle bacilli by the intra-abdominal inoculation of guinea pigs, and in 2 samples, or 2.7 per cent of the 73 specimens tested, virulent tubercle bacilli were recovered.

The ease with which tubercle bacilli may be eliminated by the udder was strikingly illustrated by an experiment conducted by the British Royal Commission, in which a cow injected with human tubercle bacilli under the skin of the shoulder began excreting tubercle bacilli from the mammary gland seven days later, and continued to do so until its death from generalized tuberculosis thirty days after inoculation. Furthermore, Titze, of the Kaiserliche Gesundheitsamte, proved that human tubercle bacilli when injected into the jugular vein of milch cows may be excreted with the milk. In the first experiment the excretion of the bacilli began in the third week and continued until the one hundred and forty-fourth day. In a subsequent test tubercle bacilli began to be excreted after twenty-four hours, but no bacilli could be found after ninety-nine days. In both these cows only the milk from the left hind quarter proved to be infectious.

It has been shown by Gaffky and Eber in Germany and Schroeder in this country that, even when the tubercle bacilli are not being excreted by the udder, the dust and manure of the stable where the diseased animals are kept are in many cases contaminated with tubercle bacilli. This contaminated material may readily infect the milk during the process of milking, even though the milk comes from a healthy cow. The importance of this method of infecting milk can not be too greatly emphasized when it is known that cattle in prime condition, without any udder lesions but with alterations confined to the lungs, frequently raise tuberculous mucus into the pharynx while coughing, then swallow this material, and thus contaminate the feces. In a recent examination at the Bureau of Animal Industry Experiment Station of the manure passed by 12 cows just purchased from dairy farms supplying milk to the city of Washington and affected with tuberculosis to an extent demonstrable only by the tuberculin test, tubercle bacilli were found in over 41 per cent of the cases, by both microscopic examination and animal inoculations. The danger from this method of infecting milk is impressed upon us as consumers when we consider the prevalence of tuberculosis in dairy herds as disclosed by numerous tests.

PREVALENCE OF TUBERCULOSIS AMONG COWS SUPPLYING MILK TO THE DISTRICT OF COLUMBIA.

Judging from the results of recent tuberculin tests, it is believed that on an average between 15 and 25 per cent of all the cows which supply milk to the District of Columbia are tuberculous. From April, 1907, to June 30, 1909, the Bureau of Animal Industry supervised the testing of 2,471 cattle in herds supplying milk to the District, with the result that on the first tests 377, or 15.25 per cent, were found tuberculous. Many other tests have been made by local veterinarians of which the bureau has no records. The percentage given is scarcely a fair estimate of the extent of tuberculosis in the dairy herds of this vicinity, since our tests include many herds which have either been cleaned previously by private tests or which have such a healthy appearance as to remove all suspicions of tuberculosis on a physical examination. Until November 26, 1909, these tests had all been voluntary on the part of the dairymen, and it is pleasing to note the large number who have had their herds cleaned of tuberculosis and the premises disinfected.

On the above date the Commissioners of the District of Columbia issued an order providing for the compulsory tuberculin testing of all cattle within the District, with the view to the suppression and prevention of this disease. As a result of this regulation practically all the cattle in the District have now been tested with tuberculin, and the results show that of the 1,701 cattle tested 321, or about 19 per cent, were tuberculous.

DANGER FROM TOXIN IN MILK OF TUBERCULOUS COWS.

Aside from the danger of tubercle bacilli in milk, some investigators (Le Blanc, Ripper, Jemma, and De Michele) consider the milk of tuberculous cows dangerous even when bacilli are not present, on account of the toxin it contains. Michellazzi has injected such milk into tuberculous animals and obtained a reaction.

ELIMINATE TUBERCULOUS CATTLE OR PASTEURIZE MILK.

To eliminate all tuberculous cattle from the herd or to pasteurize all milk coming from untested cattle should therefore be the object of all producers of milk, and sanitarians will be remiss in their whole duty should they neglect to guard against the products of tuberculous animals in their attempts to eradicate tuberculosis from man. This view was crystallized in a resolution adopted by the International Congress on Tuberculosis held at Washington in September, 1908, as follows:

Resolved, That preventive measures be continued against bovine tuberculosis, and that the possibility of the propagation of this infection to man be recognized.

TUBERCLE BACILLI IN OTHER DAIRY PRODUCTS.

Since milk is so often infected with tubercle bacilli, it is very evident that food products made from milk without submitting it to lethal temperatures during the process of their manufacture must frequently harbor virulent bacilli in undesirable numbers.

The investigations of Rabinowitsch, Klein, Laser, Bang, Petri, Dawson, Markl, Moller, and many others have conclusively shown that tubercle bacilli may be present in butter, buttermilk, margarin, and cheese when these products are offered for sale. Butter made in the customary manner and stored under the ordinary market conditions until time of sale, if dangerous through the presence of tubercle bacilli at the time of its manufacture, may retain its virulence through several months. This statement has been adequately proved by two series of experiments recently performed by the Bureau of Animal Industry.

In one series by Mohler, Washburn, and Rogers three samples of butter were tested. The first was made from milk to which bovine tubercle bacilli had been added just before churning. They were obtained from a luxuriantly growing culture upon glycerin bouillon. Ten centigrams were removed from the surface growth of the flask, carefully mixed in a sterilized solution, and added to 10 gallons of milk. The second sample was made from milk obtained from a cow affected with tuberculosis of the udder. In this milk tubercle bacilli of extreme virulence were present in great numbers. Both the first and second samples of butter were salted in the usual proportions of 1 ounce of salt to a pound of butter. The third sample was similar in every respect to the second, except that it was left unsalted. These samples of butter were tested upon guinea pigs, not only when first made, but also after storing for ten days in the ice chest, after holding in cold storage for sixty days, and again after retention in cold storage for a period of five months (one hundred and thirty-three days). The results showed that each of these samples harbored virulent tubercle bacilli throughout the entire storage period, and that at any time they were capable of infecting guinea pigs with tuberculosis if injected into the peritoneal cavity, and if the tuberculous butter was fed to the animals generalized cases of tuberculosis were still capable of being developed. In these experiments 10 guinea pigs were fed upon each butter sample for three consecutive days and 6 were inoculated with the same kind of material. Six weeks later they were chloroformed and the visceral organs of each were carefully scrutinized that every trace of tuberculosis might be detected. None of the lots of guinea pigs remained entirely free of tuberculosis, although those animals which were fed upon the contaminated butter failed to contract the disease as frequently as those

which were injected. This experiment is to be extended further in order to determine the maximum time in which infected butter, both salted and unsalted, will remain virulent when kept in cold storage under normal trade conditions. As the temperature in the cold-storage rooms is very low, the evidence shows that the tubercle bacilli are held unchanged in the frozen butter for a long period, but that they slowly lose their vitality.

In another series of experiments by Schroeder and Cotton, of the Experiment Station of the Bureau of Animal Industry, butter was made from the milk of a cow affected with udder tuberculosis. After salting at the rate of 1 ounce of salt to a pound of butter, the butter was kept without ice in a cellar at 60° F., and from time to time, up to one hundred and sixty days from the making of the butter, guinea pigs were inoculated with portions of the butter. More than 60 guinea pigs were thus inoculated and, with the exception of 5 that died prematurely and 1 that was killed, all died of generalized tuberculosis, and the one that was killed was also found affected.

In cheese, also, tubercle bacilli may become mixed up with the curd during the process of manufacture, and they have been shown to remain virulent for over three months. As a result of Galtier's experiments conducted with cheese, both salted and not salted, which was found to contain tubercle bacilli when 2 months and 10 days old, he concluded that coagulated milk, cheese, and salted cheese made from the milk of tuberculous cows may infect man, and that the by-products fed to swine and chickens may infect these animals. In experiments made in Switzerland to determine the fate of tubercle bacilli in cheese, it was demonstrated that they died between the thirty-third and fortieth day in cheese made after the Emmental method, but considerably later in cheese made approximately after the Cheddar method. An emulsion of tubercle bacilli was added to milk at the same time as the rennet, and cheese was made from the milk in the manner required to obtain Cheddar cheese. From the time of manufacture average samples of the cheese were taken weekly, macerated in sterile water, and filtered. Guinea pigs were inoculated with portions of the filtrate, and it was found that the germinating power of the tubercle bacilli lasted one hundred and four days, but after one hundred and eleven days they were incapable of conveying the disease to guinea pigs by inoculation. Harrison concluded that these experiments justify the statement that Emmental (or Swiss) cheese may be eaten with safety, as the period of ripening is much longer than the period during which the bacilli become innocuous. Cheddar cheese, he states, is seldom eaten under four months from time of manufacture, and during this period the tubercle bacilli lose their vitality. Notwithstanding this, however, Harrison recom-

mended the pasteurization of the milk in order to make the cheese absolutely safe. In a recent investigation conducted by the writer in cooperation with Doane, tubercle bacilli have been demonstrated by guinea pig inoculations in cheese one hundred and twenty-two days old, made after the Cheddar method.

In manufacturing margarin the method commonly employed is to subject the finely comminuted fat to a temperature not to exceed 50° C. for one and one-half hours. Sour milk is then added and the whole mass is thoroughly mixed; dairy butter is next added, and a certain proportion of oils (cotton, palm, cocoanut, etc.). Enough of one or more of these oils is added to lower the melting point to that of dairy butter. Hence it will be seen that artificial butter thus made may be infected in three ways: First, from the fat secured from the original cattle, as tubercle bacilli will withstand a temperature of 50° C. for some hours; second, from the butter or soured milk that has been added; and, third, from contamination during the course of its manufacture. Morganroth made examinations of 20 samples of oleomargarin, purchased in the open market, and proved the presence of virulent tubercle bacilli in 9 of the specimens.

Other products which occasionally are consumed by people, but are used more extensively as food for live stock, will also serve to convey tubercle bacilli from infected milk to those that are allowed to consume them. Thus whey from cheese factories and buttermilk and separated milk from public creameries are all offenders in this respect and have been incriminated, especially in the feeding of hogs and calves.

OTHER DISEASES AND CONDITIONS.

Foot-and-mouth disease, anthrax, cowpox, and rabies may be transmitted by the milk, and while no case of actinomycosis in man has been traced to the use of milk, it is desirable that the sale of milk from cows so affected should be prohibited, especially when the disease affects the udder. Such conditions as gastro-enteritis, milk sickness, and septic febrile conditions may render the milk injurious to the consumer. Local diseases of the udder, such as botryomycosis, mammitis, mastitis, etc., may render the milk unwholesome, especially when pus organisms are present. The color, taste, and odor of milk may be altered so as to make it unpalatable, if not unwholesome; these changes may be due to the food of the cow or to bacterial changes in the milk after it is drawn from the udder. Milk may acquire poisonous properties from the food eaten by the cow. The milk produced shortly before or during the first five days after parturition should not be used.

RECOMMENDATIONS.

In view of the facts above enumerated, the following recommendations are made as a basis for laws and for regulations by public-health officers:

1. That all cows on dairy farms producing milk for market purposes be tagged, tattooed, or otherwise marked for identification.

2. That all milk produced on such dairy farms shall either come from tuberculin-tested cattle, which shall be retested at least once a year, or be subjected to pasteurization under the supervision of the health authorities in case the herd is not tuberculin tested.

3. That no additions to any herd, whether the herd has been tested or not, shall be made in the future without subjecting the additional cattle to the tuberculin test.

4. That no license for the sale of milk shall in future be granted except to applicants having herds free of tuberculosis.

5. That the milk of cattle showing any of the udder affections above mentioned, or anthrax, rabies, gastro-enteritis, septic conditions, or clinical symptoms of tuberculosis, shall not be utilized as human food, even though the milk be pasteurized. Milk from cows fifteen days before and five days after parturition shall likewise be excluded.

6. That veterinary inspectors of the health department make frequent visits to dairies having untested herds, in order that they may discover all advanced cases of tuberculosis, or udder tuberculosis, as early as possible.

7. That the various States pass laws granting an appropriate indemnity to all owners of tuberculous cattle which come under their respective jurisdiction, the said animals to be slaughtered in abattoirs having federal or other efficient inspection.

III. THE RELATION OF THE TUBERCULOUS COW TO PUBLIC HEALTH.

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INTRODUCTION.

The International Congress on Tuberculosis at Washington in September, 1908, expressed the important conclusion, almost without a dissenting voice, that bovine tuberculosis, or tuberculosis among dairy cows, is a menace to public health of altogether too great importance to be ignored.

One result of Dr. Robert Koch's address at London in 1901, in which he announced his view that human and bovine tuberculosis are not identical diseases and that bovine tuberculosis is a negligible factor for the health of mankind, is the new life that was infused into investigations concerning all phases of the tuberculosis question. Everywhere investigators endeavored to prove or disprove Koch's announcement, and hence the conclusion of the international congress in 1908 has behind it the enormous mass of evidence collected during seven long years by diligent, scrupulous, impartial, and intelligent seekers for truth. It is not a hastily drawn conclusion or a conclusion based on inadequate evidence, neither is it the conclusion of a single man or of a few co-workers, but it is the nearly unanimous conclusion of those who are best qualified to weigh the evidence and to judge what it signifies, and hence it is the conclusion on the relationship of bovine tuberculosis to public health which, for the time being, we can not reasonably refuse to accept.

Though Koch reiterated his former view at the congress referred to, most of his arguments have fallen. For example, it has been shown that tuberculous lesions in persons, especially children, are frequently due to tubercle bacilli of the bovine type; that tubercle bacilli isolated from human tuberculous lesions may be more virulent for cattle than the bacilli commonly isolated from bovine tuberculous lesions; that tuberculosis of the organs of digestion and associated structures is much commoner than it was formerly believed to be; that the localization of tuberculous lesions in the lungs does not prove that the infection was inspired with the air; that the seat of tuberculosis in the body gives no clear idea of the portal through which the infecting organisms gained entrance; that tubercle bacilli may pass through the intestinal mucosa without affecting it and cause tuber-

culous processes in remote portions of the body, the lung and elsewhere; that the tuberculous processes in the lung commonly originate from the finer blood capillaries and not from the finer ramifications of the air channels, and consequently are attributable to tubercle bacilli that reached the lung with the blood stream; that the type of the tubercle bacillus, human or bovine, is not constant, and that the two types of bacilli, human and bovine, are connected by transition forms, so that one type merges gradually into the other.

As tuberculosis is alike the commonest disease of persons and cattle, and as persons and cattle are the commonest victims of tuberculosis, it is important for the protection of public health to know how tubercle bacilli are scattered from the bodies of tuberculous cattle and how they are introduced into the bodies of persons.

FACTS SHOWN BY EXPERIMENTS.

At the Experiment Station of the United States Bureau of Animal Industry the following facts were demonstrated:

1. The commonest way in which tubercle bacilli leave the bodies of tuberculous cattle is per rectum with the feces. Tuberculous cattle also expel tubercle bacilli from their mouths and nostrils, directly with their milk, and rarely with their urine. The tubercle bacilli expelled per rectum have their origin in most instances in the lung and throat, from which regions they are coughed up, swallowed, and passed through and out of the digestive canal without loss of pathogenic virulence.

2. The cattle that pass tubercle bacilli per rectum are not always visibly diseased; about 40 per cent of apparently healthy but tuberculous cattle, which are not known to be tuberculous until they are tested with tuberculin, intermittently pass tubercle bacilli from their bodies per rectum with the feces. This work of the Experiment Station has been confirmed by the work of the British Royal Commission on Human and Animal Tuberculosis. (See "Third Interim Report," London, 1909. A comparison of this report with Bulletin 99, May 11, 1907, and Circular 118, December 21, 1907, of the Bureau of Animal Industry, United States Department of Agriculture, is interesting.)

3. The commonest impurity in market milk is cattle feces. The amount of feces in market milk varies from a microscopic trace to a sediment clearly visible to the naked eye. Some samples of milk that show no sediment produce cream discolored precisely like the cream from milk heavily contaminated with feces; such milk must be regarded as exceptionally dangerous and dirty, but unusually well strained.

4. The union between cattle feces and the tubercle bacilli they may contain is not firm. The bacilli are evenly and loosely distributed throughout the entire mass of feces, from which, when they enter

milk, they become detached and float free. Guinea pigs inoculated with normal, fresh milk from healthy cows to which small amounts of feces from tuberculous cows were added contracted tuberculosis as readily when the milk was used in a strained as in an unstrained condition; hence tubercle bacilli introduced into milk with the feces of tuberculous cows can not be removed by straining.

5. When milk is allowed to stand for cream to rise, or when cream is separated from it rapidly in a centrifuge, the tubercle bacilli it may contain rise as abundantly with the cream globules as they gravitate with the sediment. This holds true when pure cultures of tubercle bacilli are added to milk, when the tubercle bacilli are added in the form of infected feces, when they are added in the form of pus from a tuberculous abscess, and when they are present because of a tuberculous condition of the udder. Hence cream from tuberculous milk, volume for volume, contains more tubercle bacilli than the milk. It must be clearly evident from this that no system of purifying milk from bacteria that depends upon gravity or centrifugal force is reliable.

6. Butter made from cream obtained from infected milk contains tubercle bacilli. This was proven by making butter from the milk of a cow affected with udder tuberculosis and by making it from the milk of a healthy cow to which small masses of feces from tuberculous cows had been added. The butter on inoculation into guinea pigs caused typical, generalized, fatal tuberculosis.

7. The bland, opaque character of butter, either salted or unsalted, forms an ideal environment for the preservation of the life and virulence of tubercle bacilli. Tubercle bacilli were found to show no appreciable attenuation in ordinary salted butter in forty-nine days, to be still highly virulent after ninety-nine days, not to have lost their pathogenic virulence after one hundred and thirty-three days, and to be capable of causing generalized fatal tuberculosis in guinea pigs after one hundred and sixty days.

As the investigation of the Experiment Station of the Bureau of Animal Industry to prove the long-retained virulence of tubercle bacilli in butter called out a public criticism to the effect that it was not fair to draw practical conclusions about the persistence of this virulence from the inoculation of guinea pigs, the following experiment, which may be more convincing, was made: Four healthy hogs, proven to be free from tuberculosis by the use of tuberculin, weighing 125 pounds each, in addition to their regular food were each fed 1 ounce of tuberculous butter daily for thirty days, or one month. Each hog thus received less than 2 pounds of butter during the month, or less than is usually eaten by persons of the same weight. The butter was made with cream obtained from milk naturally infected with tubercle bacilli, and every particle of this butter, which was

salted at the rate of 1 ounce of salt to the pound, was three months old or older at the time it was fed to the hogs. The hogs were kept under conditions under which no hog among the many used at the Experiment Station ever contracted tuberculosis from an accidental or unintentional cause. As the result of feeding the butter three of the four hogs became affected with typical tuberculosis.

More direct evidence that tuberculosis may be contracted through eating infected food, or more direct evidence to prove that tubercle bacilli may remain alive and virulent in ordinary salted butter for three months or a quarter of a year, would be difficult to obtain.

8. As has been shown by numerous other investigators, it was found, contrary to the length of time tubercle bacilli live in butter, that they die very rapidly on exposure to light and drying. Sunlight is so potent a factor in the sterilization of tubercle bacilli that it is doubtful whether a sticky tough substance like tuberculous sputum can reach a sufficiently fine state of pulverization to float in the air as a respirable dust without first losing its infectious character.

THE FREQUENCY OF TUBERCLE BACILLI IN MILK.

When we bear in mind that probably not less than 20 per cent of our American dairy cows are to some extent affected with tuberculosis (the percentage among the cows in European countries is much higher) and that fully 40 per cent of all tuberculous cattle, even when they retain the appearance of health, more or less intermittently expel tubercle bacilli from their bodies with the material (feces) that is the commonest, nearly a constant, impurity in milk, we can not fail to realize that tubercle bacilli must be of frequent occurrence in the milk currently sold for use as human food, and this is precisely what we find to be true when we turn our attention to an examination of market milk.

Numerous tests of milk purchased at Washington, D. C., showed that 1 among every 18 samples contained tubercle bacilli and that 1 among every 10 dealers intermittently sold infected milk, notwithstanding that the percentage of tuberculous cows among those from which the Washington milk supply is derived seems, from the tuberculin tests that have been made, to be comparatively low.

Few dairies distribute infected milk continuously. In most instances the distribution is intermittent. This seems to be a matter of some importance, because the extent to which public health is exposed to infected milk depends rather upon the number of dairies that distribute it than upon the percentage of milk samples found to be infected among a number examined, and because experience has shown that it is practically impossible, without an enormous amount of work, to prove definitely that any one dairy constantly sells or distributes milk wholly free from virulent tubercle bacilli. For example,

one test of the milk from a dairy at Washington showed it to contain tubercle bacilli. Some time afterwards samples of milk from this dairy were tested on each of thirty consecutive days. Among the 30 samples those of the second, third, and eighth days caused typical, fatal, generalized tuberculosis in guinea pigs, and those of the remaining twenty-seven days were found to be free from tubercle bacilli. Hence the fact that this dairy was intermittently distributing tuberculous milk would have escaped detection if as many as 22 samples of milk, taken on twenty-two consecutive days, beginning on the ninth day of the actual examinations, had been tested.

Professor Eber, of Leipzig, gives some figures which are interesting in connection with the intermittent distribution of infected milk by dairies. He tested the milk sold by 70 dealers on three different dates. On the first date 6 dealers, on the second 9, and on the third 7 were found to be selling tuberculous milk. The dealers who sold infected milk on the three dates are not always the same dealers, so that if we sum up the actual number who at one time or another sold tuberculous milk we have the number 19, and this is equivalent to the charge that three examinations of the milk sold by 70 dealers showed that 27.1 per cent, or more than one in four, from time to time sold tuberculous milk. Had Eber made a few more series of tests with the milk of the 70 dealers he probably would have found that even a larger percentage from time to time sold tuberculous milk.

The manner in which tubercle bacilli are expelled from the bodies of tuberculous cattle, frequently long before the remotest symptoms of disease are manifest, teaches that we can not hope to obtain milk from tuberculous cattle or from healthy cattle exposed in the environment of tuberculous cattle at all times free from tubercle bacilli; and the intermittent character of the distribution of tuberculous milk by dairies teaches that no milk is constantly safe unless it is obtained from cows that have been shown by the tuberculin test to be free from tuberculosis and that are milked, housed, fed, pastured, and in every way kept in an environment from which all tuberculous and all untested cattle are excluded.

PASTEURIZATION AS AN EXPEDIENT.

The amount of milk that can actually be produced under the conditions required to insure its freedom from tubercle bacilli must be, for some time to come, a relatively small proportion of the total supply, and therefore we are obliged to look for some expedient through the use of which milk when it is not produced under ideal conditions can be made a safe article of food. The least expensive and most efficient available expedient is pasteurization.

Pasteurization is a definite process, which must not be confounded in our minds with sterilization, scalding, boiling, etc. The proper

pasteurization of a delicate, unstable substance like milk, strictly speaking, signifies its exposure to a degree of temperature that will not markedly alter its character, for a sufficient period of time to kill nonsporulating disease germs. The minimum effective temperature is 60° C., and this should be maintained at least twenty minutes; the maximum temperature that does not cause objectionable modifications is 70° C., and this is sufficient to kill the disease germs of commoner occurrence in milk in ten minutes. The term "pasteurized milk" should be limited to milk which has been heated between 60° and 70° C. from ten to twenty minutes. Milk heated to a higher degree, or for a shorter period of time, should be defined by some other term. It seems very desirable that some authoritative body, conversant with the milk question, should write a clear definition of just what meaning is to be attached to the term "pasteurized" as applied to milk. Possibly it would be wise to drop the word "pasteurized" altogether, and to substitute some such term as "hygienically heated milk."

The fact that tubercle bacilli in milk rise as abundantly with the cream as they gravitate with the sediment, and the two facts that the bacilli in cream are transferred to the butter made from it and in butter find an ideal medium for the preservation of their life and virulence, teach that all cream should be obtained from the milk of cows certainly free from tuberculosis, or that it should be pasteurized or hygienically heated before it is used as food in the form of cream or for making butter. It has been conclusively shown that good butter can be made from pasteurized cream.

Though pasteurization is so strongly advocated, we should not lose sight of the fact that it is, after all, simply an expedient, and as such can not be used as a final solution of the milk problem. Above all it should not be used as an excuse for relaxing our efforts to secure milk that is perfectly safe without treatment of any kind, and its use to preserve dirty and otherwise unmarketable milk should under no circumstances be tolerated. That is to say, so long as the pasteurization of milk and cream is necessary as an expedient to protect public health, let us by all means practice it, but while practicing it let us continue to insist that established standards of purity shall be maintained and that these standards shall gradually be made higher and better.

SOME REASONS FOR GUARDING AGAINST INFECTED DAIRY PRODUCTS.

When we consider the sources from which the tubercle bacilli that make tuberculosis the commonest disease with which the human race is affected are derived, it is well to remember that tuberculosis has a unique place among pathological conditions. It is one of the

relatively small number of infectious diseases that attack more than one species of animals, and it is the only known infectious disease from which practically no vertebrate species is immune. It has received more attention from investigators in the realms of both human and veterinary pathology, bacteriology, and hygiene than any other disease, and yet our knowledge regarding it has remained in many respects exceedingly rudimentary. We know, for example, so little about its period of incubation that we can not say who is right, those who believe that tuberculosis arises from infection that may enter the body at any time of life, or those who believe that it almost constantly develops from latent tubercle bacilli taken into the body during the milk-drinking period.

We do know that tuberculous lesions of greater or lesser magnitude and varying stages of activity are found on autopsy with a frequency that prompts the conclusion that few persons wholly escape the tubercle bacillus. We know that tuberculosis is a disease that develops with a peculiar frequency during those periods of life when the drain on the mental and physical forces is greatest, rather than during periods following incidents of exceptional exposure to infection. We know that the children of tuberculous parents succumb to tuberculosis—not necessarily as children—more commonly than those of healthy parents; and we know that tuberculosis is not as common among those persons who have been unusually exposed to infection as we naturally have reason to expect it to be. Men with tuberculous wives and women with tuberculous husbands, when their family records are clean relative to tuberculosis, contract the disease so rarely that their presumably intense exposure can not certainly be said to infect them more frequently than persons in general become infected.

We know that tubercle bacilli are peculiar in that they may remain alive and virulent long periods of time in circumscribed closed tuberculous lesions, and we have reasons to believe that actually latent tubercle bacilli may remain in the body indefinite periods of time without causing conditions that can be identified as tuberculosis; and, finally, we know that sensibly active tuberculosis during child life is an extremely serious disease, and most apt to have a fatal termination.

Add to this that tubercle bacilli in dairy products are either in a fresh or in a well-preserved state; that their introduction into the body is direct and occurs with the use of indispensable articles of food; and that tubercle bacilli in sputum, which were long regarded as the commonest and most active cause for the propagation of tuberculosis, are exposed to conditions that almost certainly sterilize them before the sputum can be pulverized and float in the air; and we may

conclude that, whatever chances we, as adults, may be willing to take in the form of exposure to tubercle bacilli in milk and dairy products, we should not be derelict with the exposure of children. It is for the sake of children especially, the little beings whose welfare is a sacred obligation that stands second to nothing, that the fight for pure milk should be made so strong that it will overwhelm every opposition.

INTERPRETATION OF RESULTS OF BACTERIOLOGICAL EXAMINATIONS OF MILK.

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OBJECTS OF BACTERIOLOGICAL EXAMINATIONS.

The bacteriological examination of milk may be made to detect the presence of pathogenic bacteria, or its purpose may be the determination of the number and kinds of bacteria in general which the milk contains.

It is difficult to demonstrate the presence of disease-producing bacteria in milk, and the results of an examination are so uncertain that it is rarely undertaken. The bacillus of tuberculosis may be found by special microscopic methods or its presence detected by animal inoculation but these methods can not be applied to diphtheria, typhoid fever, and other diseases transmitted through milk. The usual bacteriological examination of milk is concerned not with this class of bacteria but with the second of the above mentioned objects, which is to obtain an indication of the manner in which the milk has been collected and transported, since it is now well established that there is a direct relation between the degree of cleanliness with which milk is produced and the number and kinds of bacteria which it contains.

SOURCES AND CLASSES OF BACTERIA IN MILK.

It will be necessary before considering the interpretation of bacteriological results to discuss briefly the more important sources of bacteria in milk and the methods by which they are counted.

Milk as it comes from the udder contains bacteria; the number varies with different animals, but usually so small that it is unimportant except in dairies which undertake to produce milk with a very low bacteriological count. Most of the bacteria occurring in the udder belong to a species having little effect on milk and are easily recognized by their morphology and peculiar colonies.

The bacteria which subsequently find their way into the milk may be roughly divided into three general classes: (1) Acid-forming bacteria, (2) liquefying or digesting bacteria, and (3) bacteria which render milk alkaline or produce no apparent change.

The acid-forming group includes the true lactic-acid bacteria, which are widely disseminated and are carried into the milk from

stable dust, feces, and other dirt, and the gas and acid-forming bacteria of the coli communis and aerogenes type, which are for the most part of distinctly fecal origin.

The term "liquefiers" or "digesters" is used to designate a great variety of bacteria having little in common save the ability to excrete proteolytic enzyms which are made evident by the liquefaction of gelatin or the digestion of casein. Some of these are also acid formers, and probably come from the skin of the animal. Others are found in large numbers in the feces. These bacteria also are carried into the milk in the dust of the stable, the water or mud in which cows wade, and the dirt falling from their udders and flanks.

The third group includes all bacteria not embraced by the first two groups and covers a great variety of organisms. They are usually looked upon as having little effect on milk, and consequently as having no especial significance in bacteriological counts. It is not improbable that more careful study of some of these bacteria will show that they have a decided influence on the quality of the milk in which they are present.

SIGNIFICANCE OF NUMBERS AND METHODS.

Bacteriological examination may be made merely to determine the total bacteria without regard to the kinds present. This is of value and under many circumstances is the only determination that can be made. Numerical bacteriological standards which are unquestionably of value are necessarily arbitrary and are based on the count of total bacteria only.

Special methods are necessary to obtain any insight into the relative numbers of bacteria of the different groups occurring in milk and by the information thus obtained to form an opinion regarding the cleanliness and care observed in producing and marketing the milk. It is obvious that the correctness of the deductions depends in a large measure on the exactness with which bacteriological results can be obtained. It is not only desirable that uniform methods and media be used in different laboratories in order that results may be comparable, but it is equally important that these methods be so carefully adjusted that they do not give a distorted picture of the bacterial flora of the sample.

INFLUENCE OF REACTION OF MEDIA ON COUNTS.

The accuracy of bacteriological counts depends most of all on the composition and reaction of the media and the time and temperature of incubation of the plates. The number obtained with one set of conditions may be the maximum for the particular sample under examination, but the same conditions would not necessarily give a maximum count for another sample, nor would the error be constant,

because the relative number of bacteria of different groups is subject to great variation. This is illustrated in Tables 1 and 2, which give the results of counts made with media of varying reactions. The highest count was obtained with the medium having a reaction of +1.3, and in computing these tables it is assumed that this count was 100 per cent of the bacteria present.

TABLE 1.—*Relative numbers of bacteria obtained with media of different reactions.*

Reaction of media.	0 days.	1 day.	2 days.	3 days.	5 days.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
+0.15	3.92	1.29	2.46	0.11	0.45
+0.8	76.33	68.49	77.51	81.96	50.76
+1.3	100.00	100.00	100.00	100.00	100.00
Relative numbers of different groups:					
Peptonizers	7.1	11.1	23.8	10.2	36.3
Acid	3.5	7.4	0	8.1	27.2
Alkaline or inert	89.2	81.4	76.1	81.6	36.3

The counts to show the influence of reaction of the media were made on litmus lactose agar. The relative number of the different groups was determined by litmus lactose gelatin having a reaction of +1. On the initial count given in Table 1 the medium with a reaction of +0.8 gave 76.33 per cent of the total, while that with a nearly neutral reaction gave only 3.92 per cent of the total bacteria. This ratio changed as the proportion of lactic-acid bacteria increased, and on the fifth day, when this group had increased from 3.5 to 27.2 per cent of the total, the medium with a reaction of +0.8 gave only 50.76 per cent of the total bacteria. This variation is greater in Table 2, which shows counts made under similar conditions on the same sample of milk but in which the proportion of lactic-acid bacteria had been artificially increased.

TABLE 2.—*Relative numbers of bacteria obtained with media of different reactions, the proportion of lactic-acid bacteria having been artificially increased.*

Reaction of media.	0 days.	1 day.	2 days.	3 days.	5 days.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
+0.15	1.04	0.86	8.06	1.53	0.31
+0.8	42.91	19.88	46.51	45.45	20.12
+1.3	100.00	100.00	100.00	100.00	100.00
Relative numbers of different groups:					
Peptonizers	13.6	3.9	8.4	5.6	1.7
Acid	25.0	71.4	41.3	57.9	79.0
Alkaline or inert	61.3	24.6	50.1	36.4	19.1

On the initial count 25 per cent of the bacteria in the milk were acid formers, and the media with reaction of +0.8 gave 42.91 per cent of the total. After 5 days the acid formers had increased to 79 per cent and the count on the +0.8 media dropped to 20.12 per cent of the total. In this connection the possibility that rapidly-growing

forms may change the reaction of the media and prevent the development of colonies of other bacteria should be considered. Discrepancies in results may frequently be accounted for in this way.

INFLUENCE OF TEMPERATURE OF INCUBATION.

The influence of the temperature of incubation on the count is well known. More accurate results can be obtained by incubating for four or five days at low temperatures, but in inspection work it is frequently necessary to incubate the plates at temperatures high enough to produce a quick development of colonies. Accuracy in differential counts can be obtained only by incubating at low temperatures and allowing sufficient time for the slow-growing colonies to develop their characteristics.

INFLUENCE OF AGE AND TEMPERATURE OF MILK.

A count of the total bacteria does not always give a true indication of the conditions under which the milk is produced. In order to interpret results intelligently it is necessary to know if possible the age of the milk and the temperature at which it has been held. Clean milk which has been held several hours in a warm place may contain more bacteria than dirty milk when fresh or even after two or three days if it has been held at a low temperature. This is shown in Table 3. Samples 1 and 2 were evidently produced under fairly sanitary conditions, while No. 3 was poor milk. Nos. 2 and 3 were held at 10° C. (50° F.) and No. 1 at 20° C. (68° F.).

TABLE 3.—*Influence of temperature on relative numbers of bacteria in clean and dirty milk.*

No.	Condition.	Temperature.	Initial number of bacteria.				Number after 24 hours.			
			Total.	Peptonizers.	Acid.	Alkaline or inert.	Total.	Peptonizers.	Acid.	Alkaline or inert.
		° F.								
1	Good.....	68	39,000	5,000	10,000	24,000	106,000,000	26,000,000	24,000,000	56,000,000
2	Good.....	50	43,400	10,000	13,900	19,500	660,000	50,000	280,000	330,000
3	Poor.....	50	13,900,000	1,500,000	10,900,000	1,500,000	85,000,000	1,000,000	68,000,000	16,000,000

The initial count of sample 1 indicated the conditions under which it was produced, but after twenty-four hours it contained more bacteria than No. 3 when fresh or even when twenty-four hours old. If No. 1 had been held at the same temperature as No. 3, it would in all probability have given a count corresponding to that of sample 2.

If the history of the sample is not known, some conception of the conditions under which the milk has been produced and held may be obtained by determining the relative numbers of bacteria of the important groups. When sample 1 was twenty-four hours old the

acid-forming bacteria amounted to only 21 per cent of the total, while the count for sample 3 showed 78 per cent of acid formers when fresh and 80 per cent when twenty-four hours old. It is probable that this ratio is reasonably constant and can be used as an evidence of age and the care taken of the milk, but this can be demonstrated only by the collection of a large amount of data.

SIGNIFICANCE OF GAS-FORMING BACTERIA.

Some board of health laboratories in their supervision of the milk supply make routine examinations for gas-forming bacteria, which are considered by many authorities a good indication of the past history of the milk.

A large portion of the gas-forming bacteria probably find their way into milk directly from cow feces by unclean methods of milking. They may be introduced by particles of manure which fall directly into the milk from the body of the cow or from the dust of the stable. In some Middle Western States organisms of the colon-aerogenes group occur commonly on grass, grain, and in slough holes, therefore the gas formers in milk from cows milked in open fields may not come from a fecal source. In exceptional cases the milk may be contaminated by polluted water, which is sometimes added directly to the milk, but more often gains access by careless methods of cooling in which cans of milk are placed in well water.

The gas-forming bacteria are determined by special methods, which may be easily applied in any bacteriological laboratory. In laboratories where such tests are made the presence of the colon-aerogenes group is almost always demonstrable in commercial market milk.

Routine examination for *Bacillus coli* in Baltimore has shown its presence in 0.001 of a cubic centimeter of milk in 25 per cent of the samples in winter and 75 per cent in summer.

In interpreting the results of bacteriological examinations for gas-forming bacteria the effect of the temperature at which the milk is held must be taken into consideration. A high temperature distinctly favors the growth of gas formers, and if in warm weather commercial milk is allowed to stand without being iced the souring is often found to be due to the gas formers. Milk which in transit has been allowed to stand on a depot platform in the hot sun before it is placed in refrigerator cars may upon examination by special tests show high numbers of gas-forming bacteria. If the same milk had been held at low temperatures the same tests might have been negative.

The determination of gas-forming bacteria in milk does undoubtedly give additional evidence as to the sanitary quality of a milk.

In the Eastern States it shows evidence of contamination by cow feces and in special cases may show contamination by polluted water. In the Middle Western States the more common distribution of the colon-aerogenes group renders the test less accurate as an indication of pollution by manure. In any case, however, gas-forming bacteria in milk may be said to indicate careless methods either at the time of milking or in the subsequent handling.

At present it is impossible to set any standard for the number of gas-forming bacteria which may be allowed in a clean milk. It may be said, however, that a clean milk should give negative tests in the majority of cases when 10 cubic centimeters of milk are used.

SIGNIFICANCE OF LEUCOCYTES AND STREPTOCOCCI.

Some authorities consider the presence in milk of leucocytes or streptococci of importance as indicating a disordered condition of the udder of one or more of the cows supplying the milk. In a few cities the sale of milk is prohibited when microscopical examination reveals the presence of cocci in chains or leucocytes in excess of an arbitrary standard.

The occurrence of mastitis or similar pathological conditions of the udder results in the throwing off with the milk of an increased number of leucocytes. These are usually accompanied by pus-forming bacteria, which are easily recognized under the microscope by their morphology and their tendency to chain formation. Recent work has shown, however, that leucocytes or similar cells are always given off with the milk and that their presence does not necessarily mean that the cow is unhealthy in any way. The number occurring in the milk varies greatly even among healthy animals, and although the number found in the milk from a normal udder is almost always less than in that from an affected udder, this does not always hold, and any fixed leucocyte standard would sometimes exclude the milk of healthy animals. Moreover, the methods usually employed to estimate the number of leucocytes in milk are admittedly inaccurate and the results are subject to great variation due to imperfect technique.

A somewhat similar objection may be made to the streptococcus determination, which is based on the assumption that chain formation is peculiar to the pathogenic varieties of the streptococci. The pus-forming cocci compose one branch of a large bacterial family, which includes the ordinary lactic-acid bacteria. The difference between the various branches is usually slight and may be regarded as the assumption of some particular function in addition to those possessed in common by the entire family. Thus the essential difference between the pathogenic streptococci and some of the non-

pathogenic lactic-acid bacteria probably lies only in the ability to produce pathological conditions in the animal organism. How slight this difference is may be seen in the readiness with which the pathogenic function may be lost on the one hand or acquired on the other. The tendency to form long chains is not a peculiarity of any one branch of the streptococcus group. It may be found more uniformly among the pus-forming cocci, but is not infrequently observed in harmless cultures. However, the streptococci producing pathological conditions in the udder may cause gastro-intestinal disturbance or throat troubles in man, and several epidemics of this nature have been traced to diseased cows from which the contagion has been spread through the milk.

The presence of streptococci or unusual numbers of leucocytes in stained preparations of milk has been used successfully in detecting affected animals. The affection in the udder may be detected before the trouble has developed sufficiently to make it noticeable in an ordinary clinical examination. The value of the leucocyte and streptococcus examination can not be questioned, provided it is used as a basis for a more extended investigation. The error lies in the attempt to establish an arbitrary standard not warranted by our present knowledge and technique, and the condemnation of all milk which fails to conform to this test.

V. PASTEURIZATION, ITS ADVANTAGES AND DISADVANTAGES.

By M. J. ROSENAU, M. D.,

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The writer, in Hygienic Laboratory Bulletin 41, discusses the technical and practical side of pasteurization of milk, and recognizes that a pure milk is better than a purified milk. However, it is so difficult to obtain clean fresh milk in a large city that it is necessary to destroy the danger which so frequently lurks in raw milk.

Pasteurization is a cheap and efficient method of accomplishing this result. It has a few disadvantages which must be considered; but the fact that it saves many lives and prevents much sickness far outweighs the disadvantages, many of which are theoretical.

Pasteurization as applied to milk consists in heating it to 60° C. for twenty minutes, followed by rapid cooling. The degree of heat and time of exposure, as well as the day on which the milk was heated, should be stated in each case. In practice it is perhaps well to require either a slightly higher temperature or a little longer time than 60° C. for twenty minutes in order to provide the factor of safety necessary in large commercial operations.

There can be no more objection to the heating of milk for adults and children over three years of age than there is to the cooking of beefsteak. The simple expedient of pasteurization (which at best is only an expedient) would prevent many a case of typhoid, diphtheria, scarlet fever, Malta fever, tuberculosis, and children's summer complaint, etc.

The writer, in all his writings upon the subject of milk hygiene and pasteurization, insists upon obtaining, so far as possible, milk from healthy cows in a cleanly manner and protected against pollution and infection. This desideratum can largely be accomplished through education of the farmer, transportation agents, and dairymen, all of whom should be under strict and energetic official supervision. Inspection and education, therefore, will accomplish much; but in the present state of the milk industry it can not protect against infection. The milk problem of a large community is precisely similar to the water problem. Sanitarians have now come to the sensible conclusion that the watershed should be protected, but nevertheless the water must be purified by filtration. Similarly the

"milkshed" should be protected, but the milk can not be depended upon unless it is pasteurized.

The objections to the use of pasteurized milk, even for infant use, are gradually disappearing. It appears that pasteurization is the inevitable outcome of the future, for it will soon be generally recognized that raw milk is apt to be dangerous milk and that heated milk is the only safe milk and will remain the only safe milk for the use of mankind.

Pasteurization saves lives and prevents sickness. Weighing against this great merit we have certain disadvantages connected with the heating of milk. That there are two sides to the question may be judged from the fact that those who have given the matter careful consideration come to diametrically opposite conclusions. From a theoretical standpoint some believe pasteurization to be an unsatisfactory and very feeble way out of a very difficult situation. From a practical standpoint, others find in pasteurization our only practicable safeguard, at least until the general supply consists of good, clean, fresh milk.

One of the chief objections to pasteurization is that it promotes carelessness and discourages the efforts to produce clean milk. It is believed that the general adoption of pasteurization will set back improvements at the source of supply and encourage dirty habits. It will cause the farmers and those who handle the milk to believe that it is unnecessary to be quite so particular, as the dirt that gets into the milk is going to be cooked and made harmless. It is not proposed that pasteurization shall take the place of inspection and improvements in dairy methods. To insure the public a pure and safe milk supply should be regarded as one of the most important duties of the health officer. Whether pasteurization is adopted by a city for its general milk supply or not, no milk should be accepted that does not comply with certain reasonable chemical and bacteriological standards. This would aid the inspectors in enforcing good dairy methods. Pasteurization then must not be used as an excuse to bolster up milk unfit for home consumption. To insure this end, the health officer should have authority to condemn and destroy bad milk, whether or not pasteurization is practiced.

To obtain a good milk supply involves not only an expensive system of inspection and surveillance from the farm to the consumer but intelligence and a high degree of technical skill on the part of the producer and all others who handle the milk.

We can scarcely conceive of an inspection so thorough and constant as to prevent milk occasionally becoming contaminated with the germs of typhoid, diphtheria, scarlet fever, dysentery, tuberculosis, etc.

If our drinking water is defiled at its source we boil or filter it. It would be much better to prevent its contamination. The same is

true of milk. We prefer pure milk, but so long as we can not obtain it we must purify what we get. The situation may well be illustrated by the attitude of an eminent sanitarian in New York who in his writing and public addresses discourages pasteurization because theoretically it does not reach the source of the evil and is not as good in the end as purification of the milk supply through efficient inspection. However, when this same sanitarian is consulted by a large wholesale dealer of New York, who handles many thousands of quarts of more or less old dirty milk a day, he is confronted by a condition, not a theory, and advises pasteurization.

There is a prevalent impression that the pasteurization of milk improves that important article of diet. Heating does not render milk better in any way as a food. All it does is to destroy certain bacteria and some of their toxic products. It checks certain processes of fermentation and putrefaction, thus rendering the milk safer. On the other hand, the evidence seems clear that the pasteurization of milk at 60° C. for twenty minutes does not appreciably deteriorate its quality or lessen its food value.

Pasteurization has been accused of possessing the great disadvantage of inducing scurvy and rickets. It is generally believed that highly-heated milk is a contributive factor in the etiology of scurvy. There is certainly no evidence to show that low-temperature pasteurization such as is now recommended ever in itself induces scurvy. Thousands of children have been raised upon heated milk without the production of this disease, which is comparatively rare, especially in countries such as Germany and France, where the artificial feeding with heated milk is most popular. Scurvy is preventable and amenable to treatment. Rickets result from defective alimentation and improper hygiene and can not be laid at the door of pasteurization.

Comparative observations upon infants under the same conditions show that they flourish quite as well upon heated milk as upon raw milk. Laboratory experiments as well as clinical observations coincide with the view that heated milk is quite as digestible as raw milk. In fact, it is now claimed to be more so. Metabolism experiments indicate that the utilization of calcium and iron in the body is more complete in children fed upon boiled cow's milk than in those fed upon raw cow's milk.

One of the great objections to the pasteurization of milk is that it devitalizes it. If milk contains "life" it has probably lost the last vestige of it after it is from twenty-four to forty-eight hours old and kept under such conditions that it contains myriads of bacteria. It has been shown that heating milk to 60° C. for twenty minutes, while it kills the pathogenic organisms, does not seriously affect the enzymes and the enzymes are the nearest approach to "life" with which we are familiar in milk. The germicidal properties of milk are not seriously injured at 60° C.

Another objection frequently urged against pasteurization is that some of the bacterial toxins are not killed at the ordinary temperatures used. We do not even know the nature of these poisonous products in milk, much less their thermal death points. The true bacterial toxins are destroyed by heating to a temperature of 60° C. for twenty minutes. It must be remembered that if milk contains bacterial toxins not destroyed by pasteurization it will contain these same poisons if the milk is consumed raw. In fact the heating of the milk prevents the further formation of such injurious substances.

Pasteurization, it has been claimed, results in the destruction of the ordinary acid-producing bacteria, nature's danger signal of old milk. The heating interferes with the souring process, so that fermentation of another and perhaps more serious nature may take place without the knowledge of the consumer. It has been shown that certain resistant spore-bearing bacteria have the property of peptonizing the albumens in milk. These bacteria survive the process of pasteurization, and are thus given a free field for growth, whereas in the raw milk these bacteria are largely held in check by the growth of the lactic-acid-forming organisms. This view started with the work of Flügge and has gradually lost ground for lack of clinical and laboratory confirmation. For instance, Park and Holt found that a few cases of acute indigestion immediately followed the use of pasteurized milk more than thirty-six hours old. Samples of such milk were found to contain more than 100,000,000 bacteria per cubic centimeter, mostly spore-bearing varieties. The deleterious effects, though striking, were not serious or lasting. However, so long as the danger is suspected, it makes us cautious to keep pasteurized milk cold and use it promptly.

We are told that heating destroys great numbers of bacteria in milk, and thus conceals dirt, but Theobald Smith [a] points out—

> that from a bacteriological standpoint the pasteurization of milk will not conceal dirt, for the reason that the bacteria that come from the udder or the teats will be destroyed, but the bacteria that come from dirt are largely spore-bearing bacteria and these survive. I believe that we could control the quality of milk quite as well after it was pasteurized by bacteriological counts as before, because certain species only would grow or multiply and the indicators would be much better than to-day. If we examine a plate made from milk, for instance, nobody can tell exactly whether the bacteria are due to dirt or whether they are due to the multiplication of ordinary lactic acid bacteria, unless a very careful study of that plate be made. As a rule, if nearly all the colonies are alike, we say that they are the result of multiplication; if they are quite different then there has been a good deal of dirt added to the milk. Now, it seems to me that with pasteurization it would be possible to control the dirt in milk much better than is done to-day.

[a] Smith, Theobald. American Journal of Public Health and Journal of Massachusetts Association of Boards of Health, vol. 17, 1907, p. 200.

Further, it is said that we must not meddle with nature; that pasteurization is an artificial expedient. Nature never intended milk to be collected, transported, and fed to young mammalian animals one or two days after it leaves the mammary gland. Even when fresh, the milk of one species is not well suited to the needs of the young of another species. In the artificial feeding of infants with cow's milk, we are meddling with nature. When artificial feeding is necessary we must endeavor to obtain fresh, pure milk. If this is not possible the milk should be purified, especially in the hot weather. Each infant is a law unto itself.

Pasteurization of all of the milk supply of a community may not be desirable. The clean, fresh milk, free from contamination, may not need it. Special cases may require raw milk, but the general public should be protected against the old, dirty, and uncared for milk which forms the bulk of the supply of large cities.

The heating must be done intelligently and under the supervision of the health officer. After heating, the milk is just as liable to serious contamination as before if not more so. It must therefore be carefully guarded, kept cool, and promptly delivered.

Theobald Smith,[a] 1907, expressed the opinion that pasteurization is the inevitable outcome of the future. He says:

> It seems to me that the real difficulty of the present condition is the transmission of specific disease germs which are not easily controlled by any amount of cleanliness, and these specific disease germs, one and all of them, may be destroyed by the average pasteurization.

Sedgwick[b] voices the opinion of many sanitarians when he states that—

> when all is said and done, I agree with Professor Smith that we have got to pasteurize milk. Cooked milk is the only safe and always will remain the only safe milk for the use of mankind. Little by little the idea is spreading that raw milk is apt to be dangerous milk.

Theoretically, pasteurization should not be necessary; practically, we find it forced upon us. The heating of milk has certain disadvantages which must be given consideration, but it effectually prevents much disease and death, especially in infants during the summer months.

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[a] Smith, Theobald. Discussion of Rotch's paper on "The pasteurization of milk for public sale." American Journal of Public Hygiene, vol. 17, May, 1907, p. 200.

[b] Sedgwick, W. T. Discussion of Harrington's paper on "Some of the ways in which infection is disseminated." Journal of Massachusetts Association of Boards of Health, vol. 14, Feb., 1904, p. 41.

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